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A Motor-Driven Pneumatic Street Cleaning Machine

An interesting development of the motor-car system is its application to a power street-cleaning machine of the vacuum-cleaner type which has in the past been used to a limited extent as a horse-drawn machine equipped with a steam engine for operating the vacuum machinery. This is the Furnas machine, which (in its original form) was described in ENGINEERING NEWS some 16 years ago (May 14, 1896). The 6500-lb. horse-drawn machines (and two steam-propelled machines) were used extensively in Indianapolis for some years, and averaged 120 squares (of 10,000 sq.ft. each) in 12 hours. They were used also at Columbus, Ohio; Hartford, Conn.; Los Angeles, Calif.; Sacramento, Calif., and elsewhere. In all, about 25 or 30 of these machines were built. Complaints were made as to the smoke and the burning of the lower branches of trees along the streets. As far as cleaning of the streets was concerned, however, we understand that the machines were generally satisfactory.

With the successful development of the motor truck from the mechanical and commercial points of view it has been possible to apply the street-cleaning system to a much more convenient machine in which a gasoline engine furnishes power for both the propelling and cleaning equipment. The machine was completed last year, and has been used experimentally in Indianapolis during the past winter, but has not been put into regular service. Fig. 1 is a general view of the machine, and Fig. 2 is a sectional elevation. The machine is 19x8 ft. over all, weighs 6000 lb., and is equipped with a 60 hp. engine having four cylinders 6x6 in. This sweeper is the subject of numerous patents (the earliest dating from 1897) by R. W. Furnas (the original inventor), O. E. McMeans and Charles A. Tripp. It is manufactured by the Furnas Pneumatic Sweeper Co., of Indianapolis, Ind. The following particulars of the present machine are abstracted from a paper which was presented at the annual meeting of the Indiana Engineering Society by C. A. Tripp, who has also furnished us with drawings and other information.

The sweeping hood is shown resting on the street. This is preceded by a set of coarse brushes (or rather scratchers) which loosen any dirt that may be stuck to the street surface. The gutters are cleaned by the hood, which is hung from the frame by chains, so that it will swing 6 to 8 in. from its normal position. The machine can be driven so that the hood will press against the curb and thus cover the gutters. The dirt is taken up by the air current created by the fan and deposited in a hopper of 3½ cu.yd. capacity; this has a drop-bottom for depositing the load. The small boiler furnishes steam which dampens the dirt. This aids its separation from the air, and also forms it into a dustless mat or cake in the box, so that no dust is made when dumping, or when loading into wagons. The sectional view shows the air-circulating system, which is the special and important feature of the machine. The general plan is that the air used for sweeping is recirculated, being used over and over again, with the exception of a small amount which is taken out to provide for leakage.

The sweeping hood consists of an inner and an outer portion. The outer portion is inclosed by short curtains of canvas to which small plates of iron are riveted. These plates weight down the canvas and also take the wear due to dragging on the street. They are sufficiently light, however, to pass over the dirt, and not act as a brush or scraper. The inner portion is separated from the outer portion on the front side by a similar curtain, but on the rear side by a metal strip about ½ in. from the street surface. This is the real sweeping point. The air comes down in the outer portion at a comparatively low velocity and at substantially atmospheric pressure.

The inner portion is under the full suction of the fan. The air rushing through this narrow opening at high velocity, and in a direction practically parallel with the street picks up the dirt, which is then carried up through the opening in the center of the inner portion. This opening is connected directly to the fan suction.

From the fan, the air and dirt enter the centrifugal separator, which is directly above the hopper. Here a small amount of steam is blown in, as previously described. After the dirt has been deposited by the air current, the air leaves the separator by the central tube and returns directly to the outer portion of the hood. Within this central tube is a small pipe, which is open at the lower end and leads to the ashpit of the boiler. A small amount of the air leaves by this pipe, the amount thus taken out being equal to the inward leakage to the outer portion of the hood.

FIG. 1. MOTOR PNEUMATIC STREET CLEANING MACHINE

(Furnas Pneumatic Sweeper Co., Indianapolis, Builders.)

The pressure in the separator, and hence the amount of air leaving by the small pipe, is controlled by the damper in the passage between the separator and the hood. Indirectly, this determines the pressure in the outer portion of the hood, which is maintained at or slightly below that of the atmosphere, so that any leakage is inward, thus preventing dust. The pressures vary from 1 to 12 in. according to the condition of the street.

The steam added to the dirt and air as it enters the separator increases the weight of the dust particles and thus aids in the separation. It also dampens the mass of dirt so that dust is prevented when dumping. The air returning to the hood, and therefore the air leaving the separator by the small off-take pipe carries a fine dust which is very difficult to separate. The fire in the boiler serves as an effective filter for removing this from the small volume of air which must be discharged, while the air acts to produce draft for the fire.

The fan is driven from the rear end of the engine shaft through a cone clutch and spur gears running in oil. The power for propulsion is taken from the front end of the shaft and transmitted through a friction drive and differential jack shaft to the rear wheels. The maximum speed of travel is 5½ m.p.h., which may be reduced by the friction transmission, as required by the condition of the street being swept. The machine is operated by two men. The driver controls the steering, and the propulsion and fan speeds. The operator controls the pressures in the air system, raises and lowers the hood as required by means of two levers, fires the boiler, and dumps the dirt. It is stated that under average conditions the machine will clean 15 to 18 squares (of 10,000 sq.ft. each) per hour.

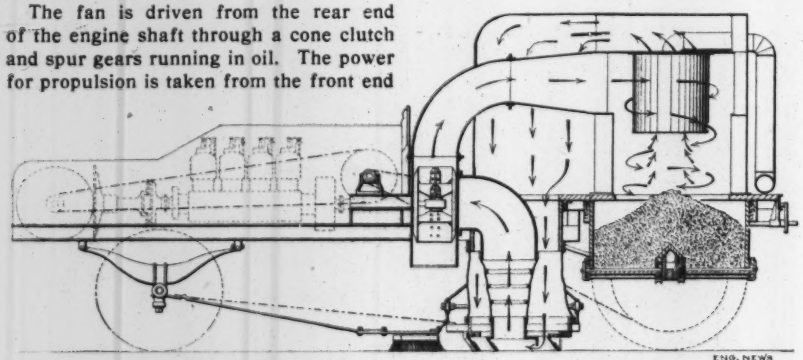


FIG. 2. SECTIONAL ELEVATION OF PNEUMATIC STREET CLEANING MACHINE

Concrete Railway Ties are being experimented with by the government of Italy on the government railways there. A number of different types have been designed and samples placed in different sections of the road where they could be kept under observation over a given length of time. It has been found that some types of ties are better than others, but all which have so far been designed seem to fail immediately under the rail bed where there appears to be a pronounced shear action which no design up to the present has been able to withstand.

Government Tests on Waterproofing and Damp-proofing of Concrete and on Waterproofing Compounds

During the maintenance of the Structural Materials Testing Laboratory at St. Louis, Mo., a series of tests were made looking into the waterproofing and damp-proofing qualities of concrete and the properties of various proprietary compounds which are claimed to have waterproofing and damp-proofing qualities. The data so obtained were delivered to the Bureau of Standards when that office took over the work of the Structural Materials Testing Laboratory and they have been compiled and published as No. 3 of the Technologic Papers of the Bureau of Standards.*

The tests include a series on 11 different mortars and 23 concretes to determine their permeability at various ages, for various consistencies and thickness of test piece and the absorption on 12 mortars at various ages and for various consistencies. In addition, a series of comparative tests were made on 40 compounds and several void-filling materials recommended for use advertised as "damp-proofing" or "waterproofing" mediums. The disfinction between terms used in the tests is stated in the report as follows:

The terms "permeability," "absorption," and "damp proof" should not be confused. A mortar or concrete is impermeable (not necessarily damp proof) as defined and used throughout this report, when it does not permit the passage or flow of water through its pores or voids. The absorption of a mortar or concrete is the property of drawing in or engrossing water into its pores or voids by capillary action or otherwise. If the pores or voids between the grains or particles or in the individual grains are sufficiently large and connect from surface to surface of the wall, the concrete will be permeable to water. If the pores or voids are very minute, but connect one with another, theoretically they may act as capillary tubes, absorbing or drawing in and filling themselves with water; but the capillary forces will tend to hold the water in the pores and will prevent the passage or flow of water, even though one surface of the wall may be exposed to a considerable hydrostatic pressure. For all practical purposes a wall under such conditions would be considered perfectly water-tight and impermeable, although it may be highly absorptive. If these minute pores do act as capillary tubes and are never minute enough to prevent capillary action, the moisture either as water or water vapor would in time penetrate entirely through and fill a concrete wall, no matter what the thickness or composition. In such a case the capillary forces would not permit an actual flow of water, but these forces may carry moisture, entirely filling the wall and, unless evaporation is retarded, the opposite face of the wall would appear dry. In such a case the concrete would be considered impermeable, but not damp proof.

The three different tests made on the various test pieces were for permeability, absorption and damp-proofness. The permeability test was made on circular test pieces 7½ in. in diameter and 1, 2 or 3 in. thick, measurement being made on the amount of water passing the test pieces under a given pressure. Some tests were made on larger test pieces, 18 in. in diameter and 6 in. thick. Concrete containing large aggregate was tested in this form. The absorption test pieces were made in 2-in. cubes and were tested by measuring the proportionate increase in weight after a fixed period of time under water. Damp-proofing test pieces were of the same size and shape as the permeability test pieces, but the surfaces were made with coarse sand, which were afterward coated with the various damp-proofing compounds. The top surface of the piece was covered with a test paper which would indicate the presence of alkaline water and the other surfaces then covered with damp-proofing compound and the piece placed in water so that the water level reached up the side of the piece, but did not cover it. By this means it was possible to detect any capillary action in the piece, for water drawn into it would pass through the piece and reach the indicator paper and on account of its alkalinity from its passing through the cement would there mark its presence. In addition to these tests, 2-in. cubes were tested in compression, and ordinary briquettes tested in tension.

From the permeability tests on the untreated concrete a number of tables with diagrams are reproduced in the report. From these tables and diagrams the following deductions may be made:

In nearly every case mortars 26 weeks old are less permeable than those eight weeks old, which in turn are less permeable than those four weeks old.

*Technologic Papers of the Bureau of Standards, S. W. Stratton, Director. No. 3. "Tests of the Absorptive and Permeable Properties of Portland Cement, Mortars and Concretes, Together with Test of Damp-proofing and Waterproofing Compounds and Materials," by Rudolph J. Wig, Associate Engineer-Physicist and P. H. Bates, Chemist, Bureau of Standards (Aug. 22, 1911).

The richer the mixture in cement the less permeable is the mortar.

A quaking consistency is less permeable than a damp consistency.

The quality of water passing decreases with the continuation of the flow.

Coarse sand mortar is more permeable than fine-grain sand mortar.

Absorption is less in quaking-consistency mortars than in damp-consistency mortars.

Absorption increases with age from the first to the second week in the damp-consistency mortars, but decreases from the second to the 26th week.

Coarse-sand mortars are slightly less absorptive than fine-sand mortar.

An endeavor was made to conduct the tests on the damp-proofing and waterproofing compounds in such a manner as to make the results of practical value as a determination of their comparative values.

Forty different compounds were purchased in the open market and several void-filling materials were obtained for testing. A complete record of each compound is reported as to its character, chemical analysis, method of application and the result of physical tests.

Considerable difficulty was experienced in devising a method of testing which would be applicable to all compounds, making the results directly comparable and at the same time complying with the directions for using the compound as recommended by the manufacturer.

The compounds are of two general classes, the waterproofing compounds for preventing the flow of water through masonry where subjected to a hydrostatic head, as in reservoirs, cisterns, tunnels, cellars, and the like; and damp-proofing compounds for overcoming dampness resulting from the capillary attraction and absorptive qualities of masonry, preventing dampness in habitations due to staining and efflorescence. Many of the waterproofing compounds are also recommended for use as damp-proofing mediums.

Two series of tests were made in this investigation, one of the waterproofing or water-resisting qualities of the compounds recommended for such use, and another of the damp-proofing qualities of other compounds so recommended to be used. Some of the coating compounds were recommended for use as waterproofing mediums, but after testing two or three and finding that they failed utterly it was decided to first test all coating compounds as damp-proofing mediums. All the waterproofing compounds tested and reported were such as were to be incorporated in a mortar or concrete and are known as "integral" compounds. No tests were made on felt papers or similar materials coated with bitumen or similar materials.

The name of each of the compounds is given in the report, but their behavior is recorded under numbers, which numbers are not assigned to the respective compound in the report, so it is impossible for the reader to ascertain the behavior of any particular compound. The compounds are classified under the headings "coating" and "integral." The "coating" class is further subdivided into "linseed oil, paints and varnishes," of which there are six; "bitumens," of which there are eight; "liquid hydrocarbons," of which there are five; "soaps," of which there are three; "cements," of which there is one, and "miscellaneous," of which there are three. The integrals are further divided into "solids," which is again divided into "inert fillers," of which there are six; "active fillers," of which there is one, and "antipathetic or water-repelling substances," of which there are eight, and "cements," of which there is one. The further division of the "integrals" is "active liquids," of which there are three.

A chemical review is then given in which the various subdivisions as noted above are each analyzed and described. Tests were made upon the permeability, absorption, damp-proofing qualities and the compression and tensile strengths according to the methods noted above, and tables and diagrams accompany the report giving the behavior of the test pieces treated with each of the various compounds, which, as noted above, are specified only by number.

Summary

As a result of the tests, the following summary is given in the report:

Portland-cement mortar and concrete can be made practically water-tight or impermeable [as defined above] to any hydrostatic head up to 40 ft. without the use of any of the so called "integral" waterproofing materials; but in order to obtain such impermeable mortar or concrete considerable care should be exercised in selecting good materials as aggregate and proportioning them in such a manner as to obtain a dense mixture. The consistency of the mixture should be wet enough so that it can be puddled, the particles flowing into position without tamping. The mixture should be well spaded against the forms when placed, so as to avoid the formation of pockets on the surface.

The addition of so called "integral" waterproofing compounds will not compensate for lean mixtures, nor for poor materials, nor for poor workmanship in the fabrication of the concrete. Since in practice the inert integral compounds (acting simply as void filling material) are added in such small quantities, they have very little or no effect on the permeability of the concrete. If the same care be taken in making the concrete impermeable without the addition of waterproofing materials as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained.

The damp-proofing tests as conducted would indicate that portland-cement mortars can be made not only impermeable but damp proof as well, as defined above, without the use of any damp-proofing or waterproofing compound. However, these tests should be interpreted with caution, as the evaporation may have been sufficient to care for the slight amount of moisture coming through the test pieces without indicating on the filter paper. Thus it cannot be stated that if a material were used which was damp proof according to this test, if used as a basement wall, one surface being constantly exposed to moisture and the other surface in an inclosed room where there would be little or no circulation of air, that the interior surface would not appear damp and the atmosphere become saturated with moisture.

The tests of coating materials as damp-proof mediums can be considered as only preliminary, but the results, considered along with the chemical discussion, throw some light on their comparative merits. The mortar used in these tests was, perhaps, too coarse and too absorptive for a fair test. The purpose of the rough surface was to test the flowing qualities of the coating, and it would seem that many of the failures may be due to the poor or imperfect spreading and adhesive quality. Several of the compounds deteriorated and proved their unfitness for the purpose intended.

Well graded sands containing considerable graded fine material are preferable for making permeable concrete, but if such is not to be had, fine material in the form of hydrated lime, finely ground clay, or an additional quantity of cement will be found of value.

Where portland-cement mortar is used as a plaster coat, if sufficient cement be used and the sand contains sufficient fine material (or a fine material be added) and the mortar be placed without joints and well troweled (care being taken not to overtrowel, which may cause crazing) the coating will be effective as an impermeable medium without the use of any waterproofing compound.

As a precaution, under certain conditions, it is undoubtedly desirable to use bituminous or similar coatings, even on new work, as protection where cracks may occur due to settling of foundation or expansion and contraction caused by temperature changes. In large or exposed work it is practically impossible to prevent some cracks, but where cracks can be prevented no coating whatever is required to make the structure impermeable.

The permeability of portland-cement mortars and concretes rapidly decreases with age.

None of the integral compounds tested materially reduced the absorption of the mortars before they were dried by heating at 212° F. Thus they would have little or no practical value. But some of the so called integral waterproofing compounds did decrease the absorption obtained after drying the mortars at 212° F., and the rate of absorption was much slower in these cases. The addition of hydrated lime and clays seemed to have little or no effect on the absorption.

The addition on any of the compounds tested to a mortar in the quantities as used in these tests does not seriously affect the compressive or tensile strength. The addition of the inert void fillers to mortars, as used in these tests, up to 20% of the volume of cement increases the compressive strength.

We have commented upon the report and its conclusions on the editorial pages of this issue.

Tunnel Lining, Catskill Aqueduct

By M. E. Zipser*

The new Catskill water-supply for the city of New York includes, north of the city line, some 31 miles of aqueduct, both under pressure and on grade and practically all in tunnel through rock. The lining of these tunnels with concrete was carefully studied by the engineers and contractors and the execution of the work has proved most successful. The following description should prove of interest to anyone having the lining of a large tunnel in hand, for the aqueduct sections approximate closely the diameter of railway tunnels.

*Assistant Engineer, Board of Water Supply, 236 Main St., Poughkeepsie, N. Y.

In the stretch of rugged country traversed by the Catskill Aqueduct which will convey water from the Catskill Mountains to New York City, a distance of approximately 100 miles, the diversity of topographical and geological conditions made it necessary to adopt several types of aqueduct. Of the four principal types, two are of tunnel construction and are known as grade and pressure tunnel. Between the Ashokan Reservoir and the northerly line of New York City, there are 24 grade tunnels aggregating 14 miles in length and eight pressure tunnels aggregating 17 miles in length.

In locating the aqueduct, wherever it was found to be more economical to tunnel through a ridge than to follow a circuitous route with the open-cut construction, or where a divide was to be passed, and the depth of the cut would have made the cost of the cut-and-cover work excessively high, the grade tunnel construction has been used. This type of aqueduct is not subjected to any internal pressure

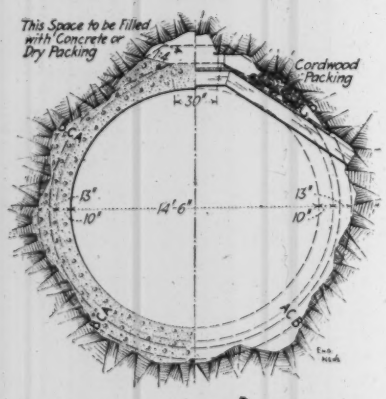


FIG. 1. TYPICAL SECTIONS OF PRESSURE TUNNELS. COMPLETED TUNNEL ON LEFT HALF. TIMBERING ON RIGHT HALF

greater than that due to the depth of water in the structure and is located, on the hydraulic gradient, either in earth or rock. Grade tunnels are lined with concrete, the interior being of a horse-shoe section generally 17 ft high by 13 ft. 4 in. wide. The wide, deep valleys along the line of the aqueduct are crossed by pressure tunnels, in the form of large inverted siphons driven through solid rock and lined with concrete, having a circular cross-section varying from 16 ft. 7 in. to 14 ft. in diameter, inside of the lining. On account of their enduring character, the pressure tunnels are preferred to steel-pipe siphons where the geological conditions are favorable. In order to carry safely the high unbalanced internal pressures when in service, the deep pressure tunnels have been placed at such a depth that there will be at least 150 ft. of sound rock above their roofs.

This article will deal with the methods which have been employed in lining the grade and pressure tunnels that are located in the Northern Aqueduct Department, which comprises that portion of the Catskill Aqueduct extending from the Ashokan Reservoir to the Croton watershed, a distance of approximately 60 miles. In this stretch are included eight grade tunnels varying in length from 560 ft. to 2.1 miles, and five pressure tunnels. The latter are, in geographical order from north to south, Rondout, Wallkill, Moodna, Hudson and Breakneck, the last three adjoining and forming really one pressure tunnel 5.5 miles long. The Rondout, Wallkill and Breakneck pressure tunnels have been entirely lined and the greater part of the lining has been placed in the Moodna tunnel. Lining is also in progress in the tunnel under the Hudson River. Of the eight grade tunnels in the Northern Aqueduct Department, six have been completely lined, and lining is in progress in the other two. The methods which have been adopted in lining the tunnels that are located in the Southern Aqueduct Department, which extends from the Croton watershed to the northerly line of New York City, are practically identical with those employed in the Northern Aqueduct Department.

TYPES OF TUNNELS—Standard types of pressure and grade tunnels used on the Catskill Aqueduct are shown in Figs. 1 and 2. On these cross-sections the *A* line defines the minimum thickness of lining, but the specifications require that the lining must average everywhere to the *C* line which is generally 5 in. outside of the *A* line. The *B* line, which is placed 13 in. from the *A* line, is the line to which the contractor is paid for excavation, and generally for concrete masonry, wherever the areas of sections actually excavated may be. The *B* line or payment quantity for the concrete in the lining of the grade tunnels of the untimbered type shown in Fig. 2 is 2.9 cu.yd. per lin.ft., while the corresponding quantity for the pressure tunnels of the type shown in Fig. 1 is 3.8 cu.yd. per lin.ft.

In order to partially compensate the contractor for the concrete placed outside of the *B* line, and at the same time not to encourage careless driving and consequent wide breakage, the number of cubic yards, if any, by which the actual quantity of concrete exceeds the theoretical quantity to the *B* line estimated in 100-ft. stretches, is allowed for payment under the specifications, as excess concrete at a price of $2.50 to $3 per cu.yd. Where the character of the rock permitted close breakage to the ordered lines, and care was taken on the part of the contractor, the actual excavation has been less than the payment excavation, resulting not

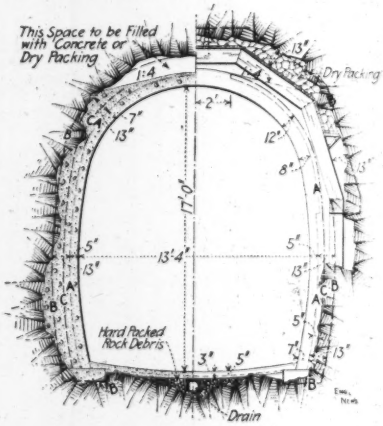


FIG. 2. TYPICAL SECTIONS OF GRADE TUNNELS. COMPLETED TUNNEL ON LEFT HALF. TIMBERING ON RIGHT HALF

only in a saving to the contractor in excavation, but also in the quantity of concrete placed. For example, in the north half of Bonticou grade tunnel driven through firm shale, the lining actually required 2.6 cu.yd. per lin.ft. against 2.9 cu.yd. paid for, and in the Wallkill pressure tunnel driven through the same material, the lining actually placed averaged 3.4 cu.yd. per lin.ft. against 3.8 cu.yd. paid for.

It will be noted that the space over the arch in the pressure tunnel in Fig. 1 is shown to be filled either with concrete or with dry packing which is to be subsequently grouted. After some experience on the Rondout pressure tunnel, it was found to be more satisfactory as regards quality of the work and cheaper both for the city and the contractor to fill this

space with concrete. Only in a few places where the roof was very high, that is, over 6 ft. was the space above the arch dry packed and grouted. All voids above the arch and back of the lining which may not be completely filled with concrete, are grouted under high pressure as described later. In grade tunnels also, the contractors have preferred to fill the space above the arch solidly with concrete except where the roof is exceptionally high, in which case dry packing is used.

In driving the headings, where the ground required support, timbering of the types shown in Figs. 1 and 2 has been used. In the grade tunnels, the five-segment timbering shown is permanent and is left in the lining. In the pressure tunnels, on account of the high internal pressures, it is not considered advisable to depend on water-soaked timber to transmit these pressures to the rock, so that any timbering that is used is for temporary purposes only and is removed before the lining is placed. The timbering shown in Fig. 1 has been extensively used both in pressure and grade tunnels to afford protection where the rock in the roof has a tendency to scale or slab off. The bents can be quickly erected without delaying the work in the heading and are removed without trouble prior to placing the lining. In rock that was considered structurally weak, or where it was thought that it would not be safe to remove any timbering if once placed, permanent steel support has been used in a few short stretches.

Features of Pressure Tunnels—The Rondout pressure tunnel is 4.4 miles long and was excavated from eight shafts varying from 370 to 710 ft. in depth. The end shafts, called the downtake and uptake shafts, respectively, are permanent shafts lined with concrete, and form part of the waterway. They are connected at the top with the aqueduct at hydraulic gradient. Shaft 5, called the drainage shaft, is to be used for unwatering the siphon for purposes of cleaning, inspection or repairs. It is offset about 75 ft. from the tunnel and connected with it by a drift in which is placed a bronze door closed and securely bolted when the tunnel is full of water. The five remaining shafts are construction shafts sunk solely for the purpose of expediting construction. They will all be closed and sealed with a concrete plug about 50 ft. thick above the roof of the tunnel. The Wallkill pressure tunnel is also 4.4 miles long, reached through six shafts varying in depth from 350 to 480 ft., while the Moodna pressure tunnel is 4.8 miles long with seven shafts from 340 to 540 ft. in depth. The Hudson River and Breakneck pressure tunnels are 3005 ft. and 750 ft. in length, respectively, the former being reached through two shafts 1187 and 1153 ft. in depth, and the latter through one shaft 589 ft. deep.

Concrete—The concrete for tunnel lining is mixed approximately in the proportions of 1:2:4 for pressure tunnels and 1:3:5 for grade tunnels. The maximum size of stone specified is 2 in. The proportions of the mix are varied from time to time as the requirements of the work demand and in accordance with the character and grading of the aggregates. As the cement is paid for separately, the engineer has absolute control over the proportions at all times, varying the mix as he may see fit. The quantity of cement per cubic yard of concrete in place has averaged approximately 1.75 bbl. in pressure tunnel and 1.35 bbl. in grade tunnel. Portland cement is used for all aqueduct structures. A moderately wet or plastic mix is used for the entire section of the lining except near the top of the arch and in the key, where a somewhat drier consistency is used. The surface of the rock against which concrete is to be placed is thoroughly cleaned by washing with water and scrubbing with brooms. On the Rondout tunnel, the pressure from the air line passing through a hose and nozzle was utilized and found to be very effective in scouring the rock and in cleaning out fissures and seams.

Pressure Tunnel Lining

Sequence in Lining—The lining for the pressure tunnels is being placed in three operations: first, the invert, which provides a firm support for the track and carriages used to move the side wall and arch forms; second, the side walls, which carry the lining up to the horizontal diameter, and third, the arch, comprising the upper half of the section. These different steps are indicated in Fig. 6. The general methods developed on the Rondout pressure tunnel, where tunnel lining was first begun, have been adopted on the other pressure tunnels, and advantage has been taken and modifications adopted, of improvements there suggested.

Concrete Plants—The concrete for the lining in the pressure tunnels has been mixed at the top of the shafts on all the tunnels in the Northern Aqueduct department except at Shaft 6, Moodna tunnel, where the mixer is set up near the bottom of the shaft. On the Rondout and Wallkill tunnels the concrete from the mixers, which were located about 40 ft. from the shafts, was dumped directly into 1-yd. steel side-dumping cars, which were pushed by hand onto the cages and after being lowered to the shaft bottoms, were hauled to the point where the lining was being placed. At Shafts 2, 3 and 5, Moodna tunnel, and at the Hudson River and Breakneck shafts the mixers are placed near the top of the shafts and discharge through chutes into cars which are filled with concrete without leaving the cages. At Shaft 6, Moodna tunnel, the sand and stone are fed from bins at the top of the shaft through chutes in one of the shaft compartments into bins in the lower portion of the same compartment. The mixer, which is electrically driven, is set up on a platform below these bins and discharges directly into the train of cars which pass underneath the platform.

Typical arrangements of the concrete plants at tops of the shafts on the Rondout and Wallkill tunnels are shown in Figs. 3 and 4. The equipment included in these plants is indicated clearly on the diagram. On the Wallkill tunnel, electric power was used to operate the mixers, the stiff leg derricks for placing the sand and stone in the bins as well as the shaft hoist and the haulage equipment in the tunnels. On the Rondout tunnel, the mixers were run by air.

On the Rondout and Wallkill tunnels, mixing plants were set up at each shaft except at the end shafts, for lining the tunnels. These plants were not all in operation at the same time, but were installed at the different shafts as fast as the excavation and trimming in the tunnel stretches adjacent to those shafts were completed; and when all the lining that was to be placed from any shaft had been completed, the plant was moved to another shaft where the tunnel stretches were in readiness for concrete operations. At one time, concrete for the tunnel lining on the Rondout tunnel was being mixed at five shafts. On the Moodna, concrete plants have been in operation at Shafts 2, 3 and 6 and it was originally planned to line the entire length of tunnel from these shafts. Recently a mixing plant was set up at Shaft 5. In this tunnel the maximum haul has been about 1½ miles. Where the conditions in regard to the availability of concrete materials, transportation facilities between shafts, etc., are favorable, it is generally more economical to operate a mixing plant at each of the shafts and thereby decrease the haul in the tunnel, as long hauls tend to cut down the speed in placing the lining. Where sand and stone are not readily available at any shaft, or where the cost of transportation to the shaft would be very high, it may be cheaper to convey the concrete a longer distance in the tunnel especially where the grades are flat and a quick method of haulage through the tunnel is provided, than to operate a concrete plant at the shaft in question. In the latter case, however, the increase in overhead cost due to delay in progress is a factor to be considered.

Tunnel Haulage—An important factor affecting the speed in placing the lining is the method of haulage through the tunnel. In the Rondout tunnel, the concrete cars were hauled by mules. The grades in this tunnel are either level or 0.1% for nine-tenths of the length of the tunnel and on these flat grades, the mules handled two loaded cars. In the Wallkill and Moodna tunnels, electric mine

locomotives have been used for hauling the concrete cars through the tunnel. The locomotives on the Wallkill were of 2½ and 3 tons' weight, with 12- and 15-hp. motors, respectively. The latter could easily pull four loaded cars up the 2% grades in this tunnel. On the Moodna, 3- and 5-ton locomotives are used, and in placing invert concrete near Shaft 6 on a nearly level grade, six loaded cars were handled by one of the 3-ton locomotives. The electric locomotives are operated by 250 volts d.c. obtained from an overhead trolley, which in the Wallkill tunnel consisted of No. 2 copper trolley wire supported by 3x6-in. timbers wedged transversely across the tunnel about every 50 ft. and placed 6½ ft. above the track. Ordinarily, the rate of placing concrete in the sidewalls on the Wallkill, using two locomotives in 3-car trains, averaged about 20 batches per hour for a 2000-ft. haul, while in the Rondout tunnel, with three mules, 12 batches per hour represented a high average under the same conditions. With mule haulage it is necessary to use enough mules and place switches and turnouts sufficiently close in order to deliver concrete at the forms as rapidly as it can be placed. The time required to place the concrete depends also on the character of the track and the condition in which it is maintained. With a poor, light track, derailments are a frequent source of trouble and delay, and the speed of operation must necessarily be cut down.

INVERT SECTIONS—The invert strip is 5 ft. wide across the top, with its sides radial, the section used being shown in Fig. 5. The forms for the invert consist of 2-in. side boards, with a 4x3-in. beveled strip bolted on the inside to form a key to engage the sidewall, as shown in the section. The forms are set accurately to line and grade and braced securely from the rock. The invert in the Rondout tunnel was at first placed in alternate panels 15 ft. long with beveled grooves in the sides and ends and screeded by means of a long piece of steel shafting. The intermediate panels were filled in subsequently and shaped in a similar manner. This method involved considerable work in having to place temporary end bulkheads every 15 ft. and made it necessary to maintain long wheelbarrow runs. It was also objectionable in introducing joints in the invert every 15 ft. This scheme was later abandoned and the invert placed continuously, which procedure was also adopted in the other pressure tunnels. Shaping of the invert surface by the continuous method is done by means of a wooden template cut to 7 ft. 1 in. radius in the 14 ft. 6 in. diameter tunnels, resting on the top of the side forms and moved along longitudinally. The 7 ft. 1 in. radius is used for the purpose of lowering the center of the invert strip slightly so that when the steel sidewall forms of 7 ft. 3 in. radius are set in place, they will bear against the sides of the invert and tend to make a tight joint at the contact. At the end of each day's work a bulkhead is put in and a groove formed at the end of the section. Shaping of the invert is done three or four hours after placing the concrete, and the surface is worked to a smooth finish by steel trowels.

The invert section first used in the Rondout tunnel was built by continuing the radial sides of the invert form to the tunnel floor by means of temporary flashboards placed to fit close to the rock in order to prevent the concrete flowing out from below. In placing this invert strip the concrete was dumped from the cars upon wooden platforms at the side of the track and carried in wheelbarrows to the forms, where it was deposited in place. To prevent their rising, the forms had to be held down by bracing the top from the rock by long struts. In placing the invert section shown in Fig. 5, which section was first used in the Wallkill tunnel, the concrete cars are dumped directly into the forms, the track being on one side and supported above the forms on 6x8-in. or 8x10-in. timbers placed transversely across the tunnel and wedged tightly at the sides. This section has the advantages over the invert section first used in the Rondout tunnel, (1) in not having to extend the bottom of the 2x14-in. invert forms to reach the floor by temporary flashboards cut to fit the irregularities of the rock; (2) in not having to clean out any muck at the sides of the invert when sidewalls are to be placed; and (3) as invert concrete is the cheapest to place, it is advantageous to use as large an invert section as is permissible. By using this section and method, the progress in the Rondout tunnel in placing invert was increased over the section and method first used from 75 ft. to 125 ft. for an average day's run for one concrete gang. A maximum weekly progress of 1500 ft. was made with work in progress at five points. In the Wallkill tunnel, 125 ft. was also the average day's run for one gang, the average weekly progress for one gang being about 600 lin.ft. The concreting in the Wallkill tunnel was done on the day shift, a typical concrete gang at the invert consisting of 1 foreman, 6 laborers, and 1 or 2 carpenters on the forms. On the other shifts the force was employed in cleaning up the bottom, setting forms, laying tracks, etc.

On the Rondout and Wallkill tunnels the practice in laying invert was, in general, to start at a point about midway between two adjacent shafts and work toward the shafts, while on the Moodna most of the invert was laid by starting near the shaft where the concrete was mixed and proceeding in a direction away from it. In the former case, as the invert work progressed, the end sections of track were taken up and the track had to be subsequently relaid upon the invert for the sidewall and arch work. In the method employed on the Moodna tunnel, some work in rehandling the track is saved, but it has the disadvantage of having to protect the green concrete and to maintain the traffic over it by leaving the 8x10-in. transverse timbers over the invert in place until the concrete is sufficiently hard to support the track and loaded cars. Also, where the water drips from the roof of the tunnel, there is greater difficulty in protecting the green concrete on account of having to keep the track clear. Usually from 450 to 600 ft. of trestling over the invert was kept in place in the Moodna where invert work was in progress.

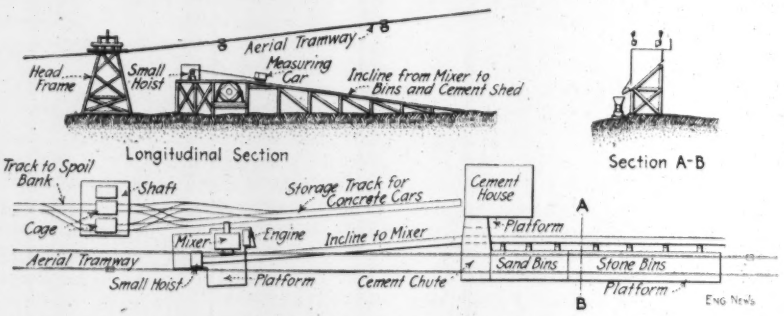


FIG. 3. TYPICAL ARRANGEMENT OF CONCRETE PLANT FOR LINING RONDOUT PRESSURE TUNNEL

SIDE WALLS AND ARCH—After the invert strip is completed between two shafts and a track laid upon it, the next step in lining is to place the concrete in the side walls and arch. The forms used for this purpose are of steel and were designed and made by the Blaw Collapsible Steel Centering Co. Those shown in Figs. 5 and 6 were in use in the Wallkill tunnel. They are of the same general design as those used in the other pressure tunnels, except that they are stiffer than the earlier design, being provided with rigid instead of loose-pin connections, and the plates are heavier. The forms shown consist of panels of curved plates ⅜ in. thick bolted to 6-in. ship-channel semi-circular ribs spaced 5 ft. on centers. The ribs are connected at the

horizontal diameter by two 6-in. channels which support a working platform of 2-in. plank from which the concrete dumped from the cars is shoveled into the side wall and arch forms. The ribs are stiffened near the lower portion by a strut consisting of two 6-in. cross-channels which are depressed at the center as shown, in order to allow sufficient headroom below the working platform for a mule or electric locomotive and train of cars to pass. The plates on the sides are bolted to each other and to the ribs by angles. The forms are collapsed by loosening the bolts connecting the ends of the horizontal channels with the gusset plates at the top of the ribs, which are then drawn inward by a pair of turnbuckles attached near the top of the vertical members shown in Fig. 5. Owing to the circular shape of the tunnel section, the T. A. Gillespie Co., the contractors on the Rondout tunnel, where the forms were first used, whereby the forms were collapsed and moved in units of 60-ft. lengths or whatever lengths were used. Special carriages which run on the completed invert, and which handle the forms with great ease and rapidity, were also designed by the contractor.

Concrete is delivered to the working platform over an incline from 50 to 90 ft. long, which is portable and so arranged that it may be taken down and moved forward on trucks in a unit with a minimum loss of time. The concrete cars are drawn up the incline by a cable from a hoisting engine which in the Wallkill and Moodna tunnels has been placed on top of the working platform at the farther end as shown in Fig. 7. Small electric hoists operated from

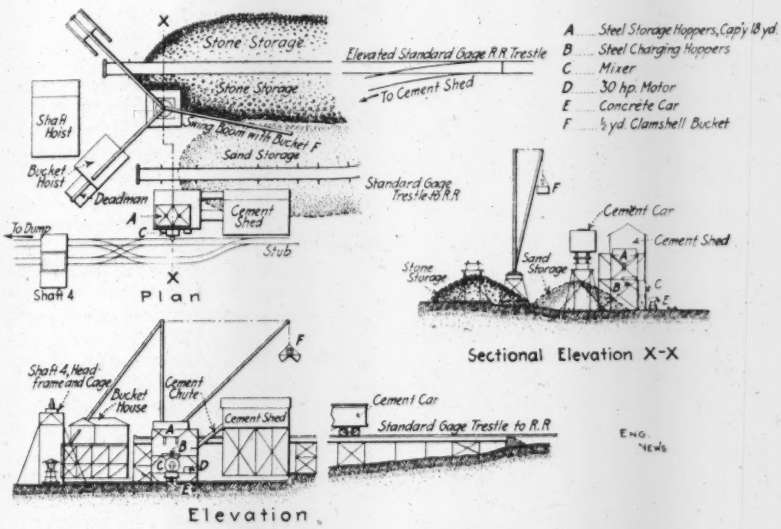


FIG. 4. TYPICAL ARRANGEMENT OF CONCRETE PLANT FOR LINING WALLKILL PRESSURE TUNNEL

these forms can be used both for the side walls and arch. The top of the side-wall forms extends about 6 in. above the horizontal diameter, and when the arch forms are in place, they overlap the side wall concrete by not less than 6 in. In the forms used for the side walls, the curved plates at the bottom of the forms over the invert are removed and the side plates allowed to overlap the invert by about 1 ft., as shown. These plates are wedged against the invert concrete at the ribs and where necessary the joint is calked tight with oakum. On the arch work, the form plates near the top are removed for convenience in placing concrete and are replaced as the concrete is carried up behind them.

As originally designed, these forms were to be taken down piece by piece and bolted up again for the next filling. This operation proved cumbersome and uneconomical and a method was devised by the trolley circuit were used for this purpose in the Wallkill and air hoists are in use in the Moodna tunnel. On the Rondout an air hoist, mounted on a truck securely anchored to the track about 75 ft. behind the rear end of the forms, was used. Here one incline and hoist were used for three sets of forms, and they were moved from one set to the other as required, whereas on the Wallkill and Moodna, a separate hoist and incline has been used for each set of forms, eliminating the time required to shift this equipment from form to form. In Breakneck pressure tunnel, the use of inclines was entirely eliminated by means of the so called "high line," which consisted of a trestle about 8 ft. high, made up of light timber bents set on the invert the entire length of the tunnel and spaced 8 ft. on centers. The top of the bents on which the rails were directly placed were on a level with the working platform. The concrete cars were moved along the trestle by a cable line operated from a hoist set up on the invert.

After the concrete cars are dumped on the platform, the concrete is shoveled by hand into place behind the forms, where it is agitated by men treading on it and spaded back from the face of the forms so as to produce a smooth dense finish along the waterway. The forms are thoroughly cleaned and greased with heavy oil before the concrete is placed. Temporary wooden bulkheads are used at the ends of the sections with a key to engage the next section. A groove is also formed along the top of the side wall to bond with the arch section.

PLACING CONCRETE IN KEY—When the concrete in the arch has reached the level of the top of the uppermost side plates, "radial" boards, usually 2x10-in., are generally placed longitudinally on either side in 5-ft. lengths, as shown in Fig. 6 and the concrete which is of drier consistency is "banked up" on a slope above the boards as shown. The radial boards are braced transversely by temporary wooden spreaders. While the "banking" is being completed, work on the key is started at the end adjacent to the old arch section by setting in place between the ribs the first key plate either 2½ or 5 ft. long, and the concrete is then shoveled into the key above the plate, by end handling. When no more concrete can be placed in the key in the first panel, the radial boards in the adjacent panel are removed, another key plate is put in place and the keying proceeds in this manner, continuing in one direction and closing on a bulkhead at the free end of the form. The concrete in the key has to be comparatively dry to be handled properly and it is rammed in place by long-handled steel or wooden tamping tools. It was the practice in the Wallkill tunnel to set a curved board transversely at each rib while keying, to act as a temporary bulkhead for the purpose of shoveling wet concrete behind it to a height of about 10 in. above the key plates, as shown in Fig. 6. Since the placing of concrete in the key is done with difficulty, the reduction of the section of the key to a minimum by use of the "radial" boards and by banking the concrete above the boards is of considerable advantage, both as to economy of time and quality of work. In the Rondout tunnel a small auxiliary platform was used above the working platform from which the concrete was shoveled into the key. The material was thus handled twice and there was room only for one man to shovel into the key. On the Wallkill the concrete was shoveled directly into the key from the working platform, which was set 6 in. higher than on the Rondout, by a gang of five shovelers who were trained to do this work with rapidity and skill.

As the time required for keying limits the speed in lining, various modifications have been tried with a view to cutting

down this time. One scheme which was used in a few sections of arch in the Wallkill tunnel consisted in employing two gangs for keying, one starting near the center panel and working toward the open end as usual, and the other gang starting at the end of the old arch and working in the same direction as the other gang and making a closure by means of a cast concrete block about 20x20 in., which was pushed through a hole in the closing key plate. The cast block had a grout pipe through its center and after the block was in place grout was pumped above and around the block by a hand pump through a hose connection. A method which was used for making closures in some sections of the arch in the Rondout tunnel is shown in Fig. 9. With this scheme, keying is started at both ends, the two gangs working toward the center, where a closure is made by sliding the closing key plate into place as indicated. A grout and vent pipe are inserted in the key for the purpose of filling the space above the concrete with grout. Another method used in the Rondout tunnel where the breakage in the roof was regular and other conditions favorable, was to place the concrete in the arch without a key by carrying up the concrete with the top surface always sloping toward the bulkhead end of the forms. At the beginning of the work in the Rondout and Wallkill tunnels, experiments were made by the contractors with a view to placing the concrete in the key by the use of compressed air, but the results were not successful.

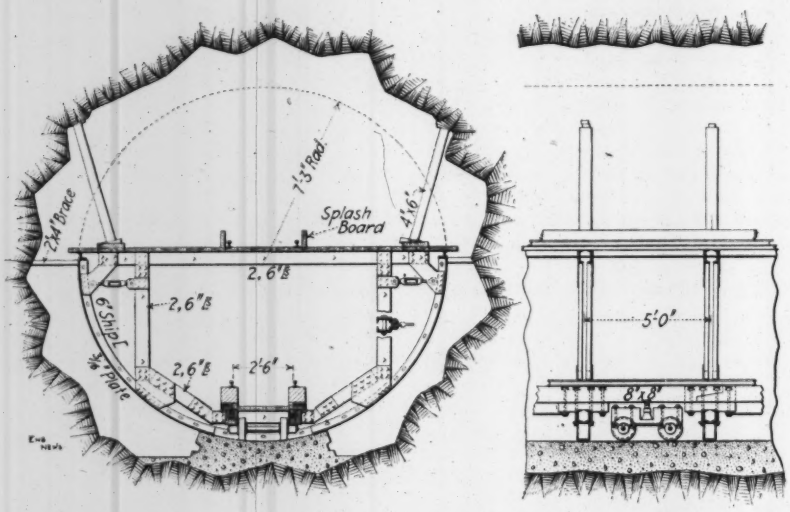


FIG. 5. SIDE-WALL FORMS AND CARRIAGE FOR LINING WALLKILL PRESSURE TUNNEL

BRACING OF FORMS—To prevent deformation of the forms and distortion of the finished section, it has been found necessary to brace the forms securely during concreting. The side-wall forms are braced against the rock along the top edge on both sides by 2x4-in. horizontal struts placed every 5 ft., and to prevent rising of the side-wall forms while they are being filled, they have to be braced by suitable vertical struts placed 5 ft. apart on each side above the horizontal channels of the forms and wedged against the rock, as shown in Fig. 5. The arch forms are braced from the roof by 2x4-in. vertical struts placed on top of each channel rib.

CARRIAGES—Practically the same type of carriages has been used in all of the pressure tunnels for handling the forms. Those used in the Wallkill tunnel are shown in Figs. 5 and 6. The side-wall carriage is mounted on small trucks with beveled wheels which travel upon the curved surface of the finished invert. The carriage blocks support an 8x8-in. stringer on either side which is bolted to the lower cross-channels of the forms, and rails are laid on these stringers to permit cars to be run through the forms underneath the working platforms. A pair of 5-in. jacks rest in seats in each carriage and bear against the under side of the stringers, as shown in Fig. 5.

When the forms are to be moved they are first collapsed by drawing in the sides about an inch on each side by the turnbuckles previously referred to, and then the entire length of form is lifted about an inch above the invert by raising the screw jacks. When the section of form is clear of the sides and bottom, it is pulled ahead into the new position by the small hoisting engine used for drawing the cars up the incline. This is accomplished by passing the cable from the drum of the hoist through a sheave wheel secured to the track ahead and attaching it to the end of the forms. The carriage for handling the arch forms is also mounted on tracks with beveled wheels which run on the completed invert. The horizontal channels which connect the ribs of the forms are supported by 6x8-in. stringers on the carriage and are lowered or raised by the screw jacks resting on the 6x6-in. posts shown in Fig. 6. The method of collapsing and moving the forms is similar to that used for the side-wall forms. Side-wall forms are left in place at least 20 hours, and arch forms 24 hours, the actual time depending on the working schedule and on the setting qualities of the cement.

LINING SIDE WALLS AND ARCH SEPARATELY—The method first used in the Rondout tunnel consisted in placing the side walls for the entire stretch between two shafts, the arch lining being started after the completion of the side walls. The general arrangement on side-wall

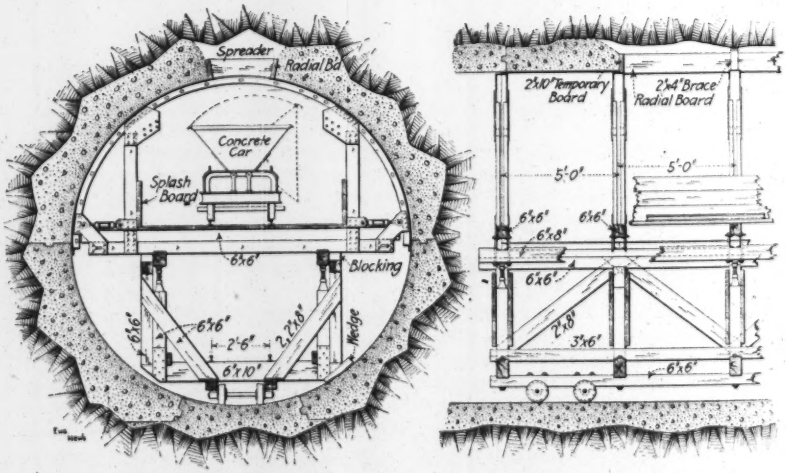


FIG. 6. ARCH FORMS AND CARRIAGE FOR LINING WALLKILL PRESSURE TUNNEL

work was to use two 60-ft. sections of forms between each pair of shafts. Between shafts 2 and 3, however, three 60-ft. side-wall forms were used, located at points dividing the distance into three equal parts. The 60-ft. length was found,

after several trials, to be best adapted for completing one section of side wall every 24 hours, and the force was organized on this basis. The work was carried on in three shifts, the filling of the forms being usually completed on the first shift, while the other shifts were engaged in cleaning up and moving and setting up the forms ready for concreting. The procedure was to fill one set of forms each day in rotation, but due to delays the progress for side-wall lining did not average over 1000 ft. per month either for two or three sets of 60-ft. forms. As soon as the side walls were completed for a given stretch of tunnel, the forms were turned over and employed for arch work. The arch forms were handled in 40-ft. lengths and it required generally about 22 hours to fill one set. Three sets of forms were used where concreting of arch was in progress and the scheme as planned was to fill each set every 24 hours. Actually, the progress for three sets of 40-ft. forms averaged about 850 lin.ft. per month. The force for placing arch was organized to concrete continuously and a concrete gang was employed on each shift.

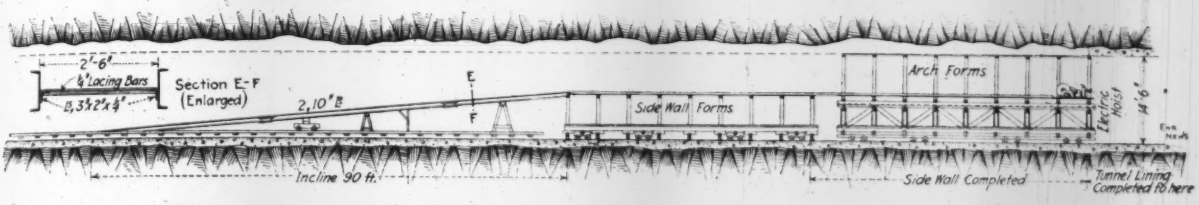


FIG. 7. INCLINE AND SIDE-WALL AND ARCH FORMS IN PLACE, WALLKILL PRESSURE TUNNEL

LINING BY "TRAILING" FORMS — The method first employed in the Wallkill and later in the other pressure tunnels, for placing the concrete in the side walls and arch, was to fill a side wall and an adjacent arch form in a continuous operation, the arch form being set up on the completed side wall about 5 ft. back from the side-wall forms; that is, the arch forms "trailed" behind the side-wall forms. The purpose of "trailing" is to provide two working points so that the concrete can be placed as fast as it is delivered, and the men can be working to advantage at every stage of the filling of the forms. The economy of this method is apparent when it is realized that the placing of the key in the arch is a slow and expensive process and as only a limited number of men can be utilized for this operation it becomes a distinct advantage when the concrete has reached the key in filling an arch form, to transfer the men that cannot be utilized efficiently in keying, to the side-wall forms. In this way when the keying of the arch is completed, the side-wall forms have been filled, as it requires considerably less time to fill the side-wall forms than it does to place the key, although the side walls take about four times as many batches of concrete as the key. Not only is there a decided gain in economy by this method, but the progress is greatly facilitated. In the Rondout tunnel, 35-ft. lengths were used when "trailing" forms and with three sets, the monthly progress averaged about 800 ft., which represented an increase in progress of over 50% as compared with the method of placing the side walls and arch separately, and practically the same force was employed in placing both a side wall and an arch section as was formerly used for an arch section alone.

ARRANGEMENT OF FORMS—Fig. 8 shows a typical arrangement of the forms in the Wallkill tunnel. The forms were concreted in rotation *A, B, C* on successive days. While *A* was being filled, form *B* was moved and set up in place; the following day, form *B* was filled and form *C* was moved, then the next day form *C* was filled and form *A* moved, completing the cycle. With such an arrangement of the forms there is never any blocking of, or interference with, the service tracks due to movement of the forms, which occurs at times when three sets of forms are placed all on one side of the shaft from which the concrete is being delivered. The forms used at the beginning in the Wallkill tunnel were in 40-ft. lengths, that is, 40 ft. of side wall and 40 ft. of arch trailing. As the men became more experienced, the unit length was increased to 45 ft., then to 50 ft. and, toward the end, 60-ft. forms were filled by one gang in the same length of time that it took formerly for 40 ft. The work was organized on a schedule basis. Concreting was started at 8:30 a.m. and the keying of the arch was completed, as a rule, before the end of the second shift. The usual procedure was to begin placing the arch concrete and to work on the arch until the concrete could not be handled as fast as it was delivered. At this stage when all the men could not work on the arch to advantage, the gang was split up, and the side walls were started. Concrete was then delivered to both the side-wall and arch forms, dumping all the cars on the platform at the side-wall forms that could not be taken care of at the arch. In this way both the side walls and the keying of the arch section were completed about the same time. With a long unit like 60 ft., and with normal breakage both in the side-wall and arch sections, all the concrete delivered can be handled at the arch until the concrete is banked above the "radial" boards and about 5 to 10 ft. of key is placed.

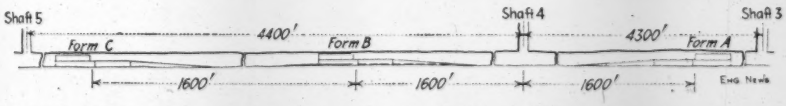


FIG. 8. DIAGRAM SHOWING ARRANGEMENT OF FORMS IN WALKILL PRESSURE TUNNEL
(Shows position of forms when starting side walls and arch lining from Shaft 4.)

The total force at the forms in the Wallkill tunnel for a 60-ft. unit consisted of 1 foreman, 16 shovelers, 6 spaders on the first shift, and 1 foreman, 12 shovelers and 4 spaders on the second shift. Five men were employed to shovel the concrete into the key and two men to ram it back. The handling of the forms was done on the day shift by a form gang, which consisted of 1 foreman, 5 carpenters, 3 helpers and 2 laborers. The side-wall and arch forms were moved separately, the former requiring ordinarily about four hours and the latter two and a half hours to collapse, move ahead and set up in place. On both shifts there was a gang of 1 foreman and 5 or 6 laborers cleaning up the bottom where the side walls were to be placed, cleaning the forms, placing drip pans, grout pipes, etc., and getting things in shape for concreting. Ordinarily, no work was done in he tunnel on the 12 midnight to 8 a.m. shift. The progress of lining in the Wallkill tunnel steadily increased, and in the month of November, 1911, when three 60-ft. forms were available and in use in the tunnel adjacent to Shaft 2, 1660 ft. of completed lining above the invert was placed from the plant at that shaft. The total number of men employed at the shaft during the month averaged 119 per 24 hours. The minimum required thickness of lining in the Wallkill tunnel is 10 in. against 12 in. in the Rondout tunnel, and, in addition, on account of the closer breakage to lines, the lining requires about 20% less concrete per linear foot

in the Wallkill than in the Rondout tunnel.

PROTECTION OF CONCRETE FROM RUNNING WATER DURING PLACING—In lining the pressure tunnels it is essential, in order to secure a dense tight lining, to protect the concrete while it is being placed and during the time of setting, from the water which enters the tunnel through the rock. Protection from inflowing water which issues through crevices in the rock or from generally seeping rock is accomplished by placing tin or galvanized-iron drip pans so as to collect the water and keep it away from the concrete during placing and setting. The water from the collecting pans runs through weepers which consist of 1½- or 2-in. steel pipes, which are embedded in the concrete and, during placing of the concrete, they are extended through holes cut in the steel forms. The pans are held in place against the rock generally by nailing the edges of the pans to wooden plugs set in holes 4 to 6 in. deep, drilled for this purpose, and by bracing them from the forms by wooden struts, which are removed as the concrete reaches them. The spaces between the edges of the pan and the rock are carefully calked with oakum to prevent the concrete from getting behind the pan and plugging the weeper. The spaces between the pans and the rock, as well as the seams, are subsequently grouted through these weepers.

In order to make it unnecessary to cut many holes through the forms for the weepers, it was originally intended to arrange the piping back of the forms so as to use a system of collectors with a few regular holes cut in the forms. It has been found more effective, however, as well as cheaper both for the city and the contractor, to use short direct pipes for grouting purposes. There are several objections to grouting through long pipes which contain bends and other connections, among them being the danger of clogging the pipes, the impossibility of drilling through a hole already grouted for the purpose of regrouting and the delays which are apt to occur in placing an arrangement of piping with complicated details. As the use of drip pans developed, it was found convenient on some portions of the work to extend the pans to weepers through holes cut in the forms at a few standard locations, and thus save the time of cutting holes. In places, also, drip pans with pipe connections were placed near the top of the side walls for subsequent use in taking care of the incoming water in the arch. The top of the pan in this case is left projecting above the side wall and the drip pan in the arch is connected to it before the concrete in the arch is placed.

In placing the invert concrete, water-bearing seams are taken care of by placing over them broken-stone drains covered with cement bags or tin and placing grout pipes so as to extend down to the drain and through the invert concrete. Wherever necessary, the drain and pipe are kept open by pumping through the grout pipe until the concrete is set sufficiently hard. In other cases the under drains are laid so as to carry the water to a low discharge at the side, and the inflowing water is pumped through the grout pipe when the side walls are placed.

TESTS OF WATER TIGHTNESS — By the methods described above for placing the concrete and protecting it while green from inflowing water, it has been possible to make the lining practically water tight. In a test, described in ENG. NEWS, Dec. 14, 1911, p. 710, the lining for a stretch of 180 ft. of ungrouted tunnel in the Wallkill tunnel was subjected to a pressure of 135 lb. per sq.in., which is equivalent to a hydrostatic head of 312 ft., and the concrete was found to be tight, the only indications of seepage through the concrete being a few damp spots, the amount of leakage at these places being negligible. Similar tests made in the Rondout tunnel showed equally good results. The writer believes

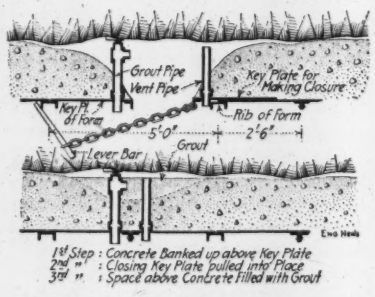


FIG. 9. A METHOD OF MAKING CLOSURE IN KEY BETWEEN ADJACENT SECTIONS OF ARCH IN TUNNEL LINING, RONDOUT PRESSURE TUNNEL

there are no tests on record of concrete construction that show such a high degree of water tightness under the stated pressure. The tests made also indicated that no outward leakage will take place through the longitudinal joints in the lining. There was some slight leakage through the transverse joints at the end of the day's work in the arch and sidewall sections. These joints open up slightly, due to shrinkage of the concrete, and in some cases, particularly in wet stretches, show slight leakage of water into the tunnel. Where these joints have been grouted, the leakage has either diminished or has stopped entirely.

GROUTING IN THE PRESSURE TUNNELS

In order to fill all voids over the tunnel arch and back of the lining, grout is forced under pressure through pipes which are set in the concrete in the arch and elsewhere at the time the lining is placed. An endeavor is made not only to fill the spaces between the concrete and the rock, and the voids in the dry packing where the latter has been used, but also to plug the crevices and water bearing seams with a view to making the tunnel "bottle tight." To prevent the formation of air pockets and insure a complete filling of the voids, vent pipes are placed at all the high places in the roof. Grouting of any stretch is not begun until at least three months after placing the lining in that stretch.

All grout and vent pipes, as well as the weepers, are steel pipes of 1½ or 2 in. diameter, each being provided at the end nearest the form with a standard coupling to which a hose connection is subsequently made for grouting. To prevent displacement of the pipes the practice in the Rondout tunnel was to extend the dry pipes as well as the weepers through the forms by means of nipples screwed into the couplings, and the ends of the couplings were kept ½ in. away from the face of the form by a wooden wedge or a piece of asket. The nipples had to be removed before the forms were struck. Grout and vent pipes are wedged between the forms and rock, the ends being left open and care is taken not to plug any pipe while placing the concrete. Where there is danger of plugging, the pipes are kept open while the concrete is being placed by poking a rod through them. On one section of the work in the Rondout tunnel, V-notches were cut in the ends of the vent pipes, which were wedged against the rock. When the holes cut in the forms for the grout and other pipes are not required, they are covered over with pieces of tin which can be easily removed.

GROUTING EQUIPMENT — Grouting in pressure tunnels has been done to date in the Rondout and Wallkill tunnels, where tank grouting machines of the Canniff type have been in use. These machines are very simple in construction and operation, consisting essentially of a tight cylinder provided with suitable pipe connections for introducing compressed air and ejecting grout. As a rule, two grouting machines are used simultaneously in grouting a section, one being charged while the other is discharging. To overcome the high ground-water heads and provide the required grouting pressures, small Westinghouse air compressors are used which take suction from the air line and boost the pressure from 100 lb. up to 300 lb. per sq.in. The grout machines and compressors are mounted on the lower platform of a double-deck car, the upper deck of which is used as a working platform for making hose connections to grout pipes. High-pressure hose, wire wound, and about 25 ft. long, is used for grouting purposes. A by-pass valve is placed at the pipe end of the hose to blow out the hose without disconnecting, and to permit the escape of air from an unvented pocket while the hose is filling with grout. As the grout-

ing progresses, the holes which show a flow of grout are closed either by plug-cocks or by driving wooden plugs into them.

METHOD OF GROUTING—In order to confine the flow of grout, and to grout the tunnel arch in short stretches, the specifications call for the construction of masonry cutoff walls to be built over the tunnel arch and tight against the roof, not more than 50 ft. apart. An attempt was made to build these cutoff walls in the Rondout tunnel by ramming concrete tight against the rock at low spots, and also by calking with oakum and cement the shrinkage space in the arch between the concrete and the roof at the end of each section of arch placed. Where these cutoff walls proved to be tight, the grouting of the space over the arch was started by connecting to the lowest grout pipe in the stretch being grouted, and making subsequent connections to pipes whose upper ends were at higher elevations after these pipes showed a flow of grout. The grouting was started under a low pressure of about 75 lb., which was raised until no more grout could be forced through the holes under 300 lb. per sq.in. Any weepers in the stretch being grouted were left flowing water and were grouted subsequently. It was found, however, when grouting operations were begun in the Rondout tunnel that the cutoff walls under high pressures did not generally retain the grout which would travel for long distances beyond the cutoff walls. The flow of grout beyond the cutoff walls indicated that even where efforts are made, it is practically impossible to pack the concrete tight up against the roof, and that a small but continuous void exists along the top and haunches of the arch which is subsequently filled with grout. In the Rondout tunnel this space above the arch has taken about 4 cu.ft. of grout per lin.ft. of tunnel.

The method of grouting which was later adopted on one section of the work in the Rondout tunnel, after the method originally contemplated was abandoned, was substantially as follows: When placing the lining, grout pipes were set at low spots in the roof, generally about 75 ft. to 100 ft. apart with a vent pipe about 10 ft. from each grout pipe, and vent pipes were also placed at the high points in the roof, as shown in Fig. 11. Grouting was done in three stages. At first a grout cutoff wall was formed at each of the above low spots by forcing grout through the low pipe until the grout flowed from the adjacent vent pipe whose upper end was at a higher elevation. This grouting was done under a low pressure, usually from 30 to 40 lb. If any weepers showed grout during this stage, they were closed and the holes were reopened about 12 hours later by cleaning out the pipes with a rod. These holes were subsequently connected up for high-pressure grouting. After the grout cutoff walls had been formed for a stretch of tunnel, the second stage consisted in grouting the sections between the cutoff walls, starting with a pressure of 100 lb. and raising it to 300 lb. per sq.in. When no more grout could be forced in under this pressure the high vent pipes were opened and any water that had accumulated was allowed to run off. After a stretch of tunnel was grouted in this manner, all the valves were opened, the plugs at the ends of pipes were removed, and any hole that was open or that showed a flow of water was connected up and grouted under a pressure of 275 to 300 lb. In the Rondout tunnel, in addition to the other grout pipes, three pipes were generally placed at the end of each day's section of arch, one in the key and one at each haunch, as shown in Fig. 11, for the purpose of grouting the contraction joint between adjacent sections of arch.

In the Wallkill tunnel, advantage has been taken of the experience gained in grouting the Rondout tunnel and the following modifications in the method of grouting have been used. No cutoff walls are constructed. The stretches are grouted at first under low pressure by forcing the grout ahead for short distances, not over 150 ft., with the idea of filling the space above the arch and blanketing the contraction joints in the concrete arch at the end of the day's work. The pipes flowing water are left open and the high vent pipes are also opened up before the grout has set. Subsequently these pipes are grouted under high pressure. The low-pressure grouting is carried on continuously on all three shifts.

The grout used in the Rondout tunnel was mixed in batches consisting of one bag of portland cement weighing 95 lb., one bag of fine sand weighing 75 lb., and 0.82 cu.ft. of water, except for high-pressure grouting, where neat cement and a higher percentage of water were used. Trials were made during the progress of the work with different percentages of water. The proportion given for a 1:1 mix (weight of water = 30% of weight of dry materials) was found to give the best results, the consistency being such that the grout flowed well without separation and did not clog the hose. The amount of cement contained in this mix is about 4.7 bbl. per cu.yd. of set grout in place. Portions of grout cut out from the work show the grout to be very dense, weighing in the case of the 1:1 mix, 134 lb. per cu.ft. saturated.

GRADE-TUNNEL LINING

In lining the grade tunnels, the same general methods employed in pressure-tunnel work have been followed, but on account of the design and shape of the section, the thickness of the lining, etc., the sequence of operations in grade-tunnel lining differs from that in pressure tunnel. Footing courses, shown in Fig. 10, are first laid along each side of the tunnel, generally for the entire length of the tunnel, before the lining of the side walls and arch is begun. The footings provide a firm support for the side-wall and arch forms, which are filled in one operation in grade-tunnel lining. After the side-wall and arch lining, which follows the placing of the footings, is completed, the invert concrete is placed.

The concrete plants that have been established for lining the grade tunnels consist of the usual standard equipment. The mixers are placed at convenient locations outside of the tunnels, near the portals, and discharge at tunnel grade, either directly or through chutes, into steel side-dumping cars of 30 to 40 cu.ft. capacity. The cars have been hauled through the tunnel by mules, each mule handling, as a rule, two cars.

FOOTING COURSES—The forms for the footing courses consist of 2-in. planks running longitudinally and braced from the track. The concrete for the footings is either dumped directly from the cars into the forms or it is first dumped on a platform from which it is shovelled into place. The top surface of the concrete is trowelled and finished smooth, true to grade.

FORMS—The forms for the side walls and arch used in the grade tunnels are of steel, designed and manufactured by the Blaw Collapsible Steel Centering Co. Those used in the south half of Bonticou tunnel are shown in Fig. 10. They consist of $\frac{3}{16}$-in. plates bolted to 6-in. channel ribs spaced 5 ft. on centers and reinforced longitudinally by angles. The ribs are braced transversely by two 6-in. channels placed slightly above the springing line carrying a working platform, and by two 6-in. channels near the bottom of the ribs supporting a track which permits cars to run through the forms underneath the working platform. Vertical braces consisting of two 6-in. channels connect the upper and lower channels on either side. The forms rest on 4-in. wooden sills, which are laid on top of the footing courses as shown in Fig. 10. The concrete is generally delivered to the working platform by means of an incline similar to the one used in pressure-tunnel lining, the cars being hauled up the incline either by small electric or air hoists placed on the working platform at the far end, or on the track about 60 ft. beyond the forms. In lining Cat Hill tunnel, which is 2350 ft. long, an electrically operated cage, which could be moved forward on small trucks resting on top of the footings, was used instead of an incline to hoist the concrete cars to the working platform, and in lining McKeel tunnel, which is 900 ft. long and where only one 30-ft. length of form was used, both the incline and hoisting engine were eliminated by the use of a platform car

propelled by mule power. The platform accommodated three cars and was at the same level as the working platform.

CONCRETING SIDE WALLS AND ARCH—From the working platform the concrete is shoveled into the forms. Above the level of the platform the form plates are erected as the concrete is placed, although the lower plates above the platform

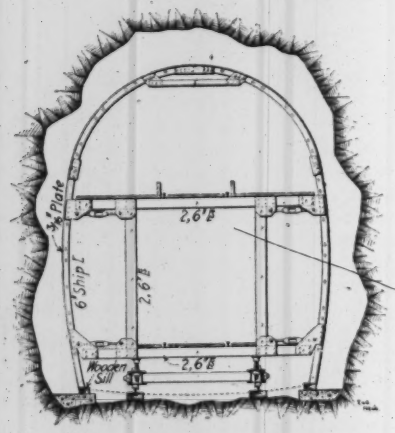


FIG. 10. SIDE WALL AND ARCH FORMS, SOUTH HALF OF BONTICOU GRADE TUNNEL

in every other panel are generally left in place on the ribs. When the concrete reaches the top of the side plates, it is banked up on either side with drier concrete and the keying of the arch proceeds by starting at the old arch section and working in one direction, the concrete being shoveled into place by end handling as in pressure-tunnel work. When the forms are ready to be moved, the ribs are unbolted at the crown, and the bolts are removed at the hinges on either side of the ribs permitting the tops of the ribs to be pulled down a few inches and after removal of the necessary bolts the sides are drawn inward by a pair of turnbuckles attached to gusset plates near the bottom of the channel posts, as shown in Fig. 10. The forms are then raised about an inch above the sills by the screw jacks on the carriages which support the forms, which are then moved forward to their new position. As with the pressure-tunnel forms, the side plates are left on the ribs up to the springing line while the forms are moved.

ORGANIZATION FOR LINING—The forms for side wall and arch in grade tunnels are generally handled in 30-ft. lengths, although 20-ft. and 40-ft. lengths have also been used. It takes usually from 12 to 16 hours to fill a 30-ft. section, the time depending on the number of yards of concrete required for the section, the length of haul, the transportation facilities, etc. Three sets of forms are generally used, and spaced in the tunnel so that each set completes its allotted stretch at the same time as the other sets. The forms are filled successively in rotation.

The side-wall and arch work in nearly all of the grade tunnels has been organized on the basis of completing a 30-ft. section, or whatever length is used every 24 hours. This scheme of organization was used in the south half of Bonticou tunnel, comprising 3400 ft., where three 30-ft. forms were employed. The concreting was done on the 8 a.m. to 4 p.m. and on the 4 p.m. to 12 midnight shifts, each concrete gang at the forms consisting of 1 foreman, 5 shovelers and 2 spaders. The forms were moved and set in place on the 4 p.m. to 12 mignight shift by a gang of about 12 men. Cleaning up and getting the forms in shape ready for concreting was done by a gang on the 12 midnight to 8 a.m. shift. Work was prosecuted six days in a week and a uniform progress of 180 ft. of side wall and arch was made each week. In lining Peak tunnel, which is 3470 ft. long, three 40-ft. forms were used, and no difficulty was experienced in filling a form in less than 16 hours. A weekly progress of 280 ft. was maintained during practically the entire time of lining.

In lining Bull Hill tunnel, which is 5365 ft. long, the work was organized so as to concrete continuously, and three concrete gangs were used, one on each shift, the concreting of a section being started as soon as the forms were ready. Three sets of forms were used, and when the keying of an arch section was about half completed, and sufficient dry materials had been placed on the working platform to complete the remainder of the key, the gang was split up, the incline to the platform was dropped, moved ahead and set up on another form which had been put in shape ready for concreting by the form gang. Filling of this form was then started, while a small gang completed the key in the other section. It took from five to six hours to strike, move and set up the forms. For the four weeks ending Dec. 20, 1911, an average weekly progress of 340 ft. of side-wall and arch lining was made, using one 40-ft. and two 30-ft. sections of forms and working three shifts every day, including Sunday. On a long haul six mules were used in the tunnel and switches were placed sufficiently close in order to deliver the concrete to the forms as fast as it was placed in the side walls.

CONCRETING INVERT — Different methods have been employed in placing the invert concrete. The bottom of the grade tunnel does not have to be cleaned of muck débris as in pressure tunnels and the invert strip is laid on the compacted muck as shown in Fig. 2.

In the south half of Bonticou tunnel the invert was laid first on one half of the tunnel for a stretch of a few hundred feet, by dumping the concrete from the cars directly into the invert, the tracks having been shifted to the opposite side of the tunnel. After a stretch of about 1000 ft. of invert had been completed on one side, and the concrete had set sufficiently hard, the track was placed on the finished invert and the remaining half built in a similar manner. Screeding of the invert was done by means of a piece of steel shafting, which was rolled along transversely to the tunnel, the ends resting on 2-in. deep wooden templates curved to the shape of the invert and set in the concrete. These templates were spaced about 18 ft. apart longitudinally and were wedged from the footings and side walls. They were removed before the concrete had hardened and the spaces filled with mortar. In Peak tunnel, where this method was adopted, an average progress of 305 ft. of completed invert was made in one eight-hour shift. In Bull Hill tunnel, the invert was placed continuously, the screeding being done in a manner similar to that employed in the south half of Bonticou tunnel.

Another method which has been used in laying invert consists in placing the concrete in alternate panels about 15 ft. long, the spaces between the sections being later filled in and the screeding being accomplished by using a piece of steel shafting which is rolled along the top edges of the invert forms, which consists of 2-in. strips of wood placed transversely to the tunnel and resting on the footing courses. The track is supported on wooden horses which are placed on either side of the panels being concreted, and the concrete is dumped directly from the cars into the invert. In all invert

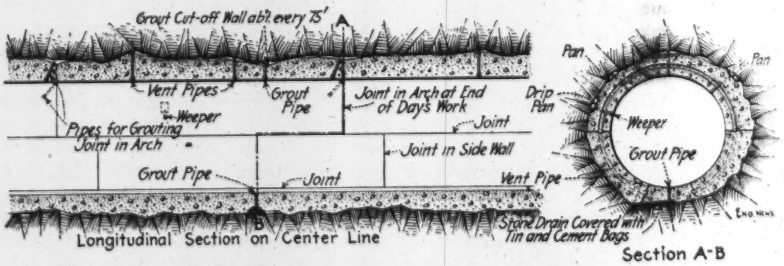


FIG. 11. TYPICAL ARRANGEMENT OF GROUT PIPES AND WEEPERS, RONDOUT PRESSURE TUNNEL

work, the top surface is troweled to a smooth finish.

Summary

In the above article an attempt has been made to describe the methods of work followed under ordinary conditions in lining some 20 miles of tunnels on the Catskill Aqueduct. In a few short stretches, it has been found necessary to adopt special methods on account of the unusual conditions encountered. For exemple, in a stretch of soft ground in Garrison grade tunnel, where considerable lateral pressures developed, making it necessary to securely brace the timbering transversely, a 14-in. thick invert was laid first, then the side walls, and finally the arch. Wooden forms were used and the side walls were cast continuously by building a form around each spreader. The spreaders were removed after the concrete had developed sufficient strength and the holes in the side walls filled with concrete.

In a wet stretch of tunnel on a 15% grade north of Shaft 4, Rondout tunnel, yielding about 1200 gal. per min., the lining was placed inside of a special longitudinal steel shell. The space between the shell and rock which had been dry packed was subsequently grouted and the leakage into the tunnel was reduced to 8 gal. per min. In the tunnel north of this stretch, where several large mud seams had been encountered in a zone of broken ground in limestone, sections of tight circular steel shell were embedded in the concrete at the mud seams to reinforce the lining and prevent the outward leakage of water when the tunnel will be in service.

The Catskill Aqueduct is being built by the Board of Water Supply of the City of New York, under the direction of J. Waldo Smith, as Chief Engineer. The work in the Northern Aqueduct Department was under the supervision of Robert Ridgway, Department Engineer, from the beginning until Jan. 15, 1912, when Mr. Ridgway resigned to enter upon his duties as Engineer of Subway Construction, Public Service Commission, First District, New York, and was succeeded by Ralph N. Wheeler, formerly Senior Division Engineer in the Northern Aqueduct Department. The construction work described is being done under different contracts as follows: The Rondout pressure tunnel and north half of Bonticou grade tunnel are included in Contract 12, the T. A. Gillespie Co., contractors; the Wallkill pressure tunnel and south half of Bonticou grade tunnel are portions of Contract 47, the Degnon Contracting Co., contractors, the grade tunnel having been driven and lined by Carpenter & Boxley; the Moodna pressure tunnel is included in Contract 20, Mason & Hanger Co., contractors; Breakneck pressure tunnel is a portion of Contract 80, The Dravo Contracting Co., contractors; Peak grade tunnel is part of Contract 11, Stewart-Kerbaugh-Shanley Co., contractors; Bull Hill grade tunnel is included in Contract 22, Receivers for Patterson & Co., contractors.

A New Type of English Dock Crane*

A balanced jib traveling crane of unusual construction has been introduced in England by Messrs. Stothert & Pitt, Ltd., of Bath. This type is claimed to be especially useful for wharf work in handling moderately light loads, and 17 of them have recently been installed for the Bristol Docks. The crane was designed by Arthur Musker, M. I. Mech. E., and is based upon what is known as the Musker and Davison system.

Fig. 1 shows a diagrammatic sketch of a crane of this type. From the pivot near the end of the counterweight arm are two

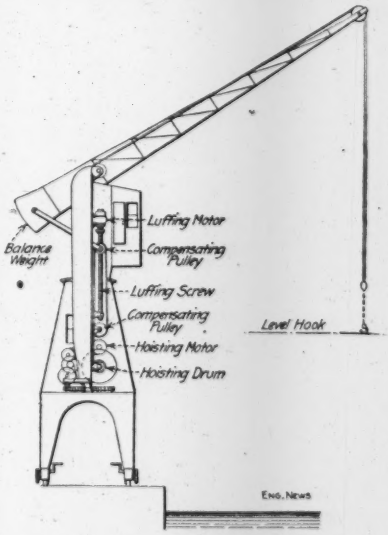


Fig. 1. Balanced Jib Traveling Crane for the Bristol Docks, England

links which are attached to a crosshead working in vertical guides on the crane column. The crosshead is moved up or down by means of a motor-driven vertical screw, as shown in Fig. 1. This, of course, gives an angular movement to the jib and moves the load to or from the crane column.

To the crosshead is attached one or more pulleys, and corresponding ones are attached to the crane column. The falls of the lifting rope pass around these pulleys before being wound on the hoisting drum below. By referring to Fig. 1 it can be plainly seen that as the jib is raised the crosshead travels down the screw, the pulleys approach each other, and the lifting rope is paid out. Similarly when the jib is lowered the pulleys separate and the lifting rope is taken in.

The arrangement of the compensating gears is such that the load remains level throughout process. How this is done

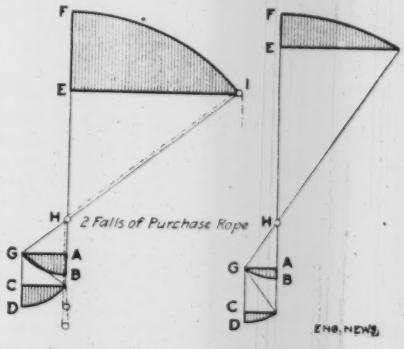


Fig. 2. Diagram Showing Relative Motions of Jib and Crosshead

is made plain by reference to Fig. 2, where it is seen that the versed sines AB and CD are proportional to EF in the same ratio that HI is to HG, or in this sketch as 1:4. The sum of the movements AB and CD, or the total movement of the crosshead then equals $\frac{EF}{2}$. The double fall of the lifting rope makes the total movement of the rope equal to EF, and hence the load remains at a constant level through any movement of the jib.

The power consumed in moving the load horizontally by angular motion of the jib is very small, amounting only to that absorbed in the friction of the rope gear, screw, etc. The cranes built for the Bristol Docks have a minimum radius of 20 ft. and a maximum radius of about 60 ft. They are designed for 2-ton loads, and the screw is operated by a 6-b.hp. electric motor running at 360 r.p.m., which gives a horizontal movement to the load end of the jib of 200 ft. per min.

The raising and lowering of the load is done by a separate electric motor geared to a drum as shown in Fig. 1. The cranes described above have a hoisting speed of 200 ft. per min. with a 2-ton load. The motor is 40 b.hp. and runs at 450 r.p.m.

The crane column is revolved by a third motor of 12 b.hp. running at 550 r.p.m., mounted on the crane column and geared to an internal toothed ring fixed to the crane pedestal platform. The whole is mounted on trucks and travels on a horizontal track, 14 ft. 11½ in. center to center rails.

*Abstract of an article in "Engineering," London, Jan. 26, 1912, p. 128.

A Large Irrigation Project in Roumania is to be the subject of a governmental investigation under a recent $20,000 appropriation. The area to be irrigated is the plains between the Danube and Bukarest, an area of 1,500,000 acres. —London "Times."

The "Heel Trunnion" Bascule Bridge

By Philip L. Kaufman*

A type of bascule bridge with fixed trunnions and overhead counterweights has been developed recently in which the center of gravity of the whole structure does not move either vertically or horizontally as the bridge is being opened or closed. The foundations for this type of bascule are therefore simple and economical. Eight bridges of this type have now been completed.

*Of the Strauss Bascule Bridge Co., Fort Dearborn Bldg., Chicago, Ill.

During the past two or three years a number of bascule bridges of a new form have been built, under the designs of the Strauss Bascule Bridge Co. This new form is known as the "Heel Trunnion" type, and is a modification of the earlier designs of this company.†

As no description of the "Heel Trunnion" type has yet appeared in technical journals, and as this design has practically superseded the earlier Strauss types, it may be of interest to illustrate its features.

Fig. 1 shows line diagrams of a "Heel Trunnion" bascule bridge. Point T is the main trunnion, located in the bottom chord of the truss, about which the moving leaf pivots; it is a fixed pivotal point. The counterweight trunnion C, also a fixed pivotal point, is located at the apex of a fixed triangular tower, about which the counterweight frame and concrete counterweight (the latter shown cross-hatched) pivot. The counterbalancing effect is applied to the moving leaf through the counterweight link $P_1 P_2$, connected to the truss and counterweight frame by means of pins at either end. This link is parallel to and equal in length to a line joining the main trunnion T and counterweight trunnion C. In like manner P_1T is parallel and equal in length to P_2C. The center of gravity of the entire moving leaf is at G, and the center of gravity of the counterweight and frame is at G'. The moment of the moving leaf about the main trunnion is Wa, in which W is the weight of the moving leaf considered concentrated at G, and a is the horizontal distance between G and T. This moment is opposed by the equal moment of the counterweight Pb, in which P is the weight of the counterweight and frame considered concentrated at G' and b the horizontal distance between G' and C. If $Wa = Pb$, the structure is in equilibrium considering the bridge closed. The condition in addition to the preceding necessary to establish equilibrium for all positions of the bridge is that line GT must be parallel to line $G'C$; they will then remain parallel as the bridge operates, by virtue of the parallelogram TP_1P_2C.

The dead-load pier reactions are constant and vertical for all positions of the bridge. It will be noted that the dead-load reaction of the rest pier is zero whether the bridge is closed or open. The dead-load reaction of the trunnion pier is practically equal to the weight of the moving leaf; the dead-load reaction of the counterweight pier is practically equal to the weight of the counterweight and tower. These conditions are brought about by the separation of the points of support of the counterweight and the moving leaf, but at the same time combining their pin reaction through the connecting members of the parallelogram, so as to cause a resultant vertical and constant load on the piers. The combined center of gravity of the component parts of the entire structure does not move either vertically or horizontally as the bridge operates. For this reason the foundations of a bridge of this type are simple and economical. Moreover, by separating the reactions of moving leaf and counterweight the evils of concentrating the entire load on one pier are avoided.

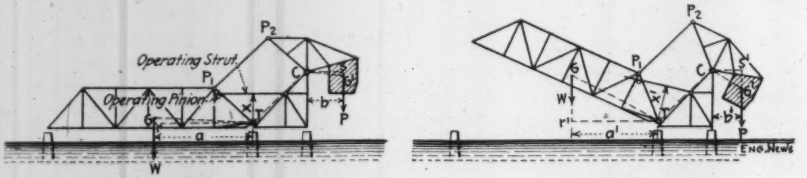


FIG. 1. DIAGRAMS OF "HEEL TRUNNION" BASCULE BRIDGE
CLOSED POSITION PARTLY OPENED

Eight large bridges of this type have been completed, and as many more of equal size or larger are under construction. As typical of the arrangement of all, Fig. 2 shows the general plan and elevation of the Northern Pacific Ry. bridge over the west waterway of the Duwamish River at Seattle, Wash., a 160-ft. span. The other bridges are: 160-ft double-track span across the Cape Cod Canal for the Cape Cod Construction Co., at Buzzards Bay, Mass., used and operated by the New York, New Haven & Hartford Ry.; 160-ft. double-track span for the Lake Shore & Michigan Southern Ry., at Ashtabula Harbor, Ohio; 160-ft. double-track span over the Illinois River at Peoria, Ill., for the Peoria & Pekin Union Ry., used jointly

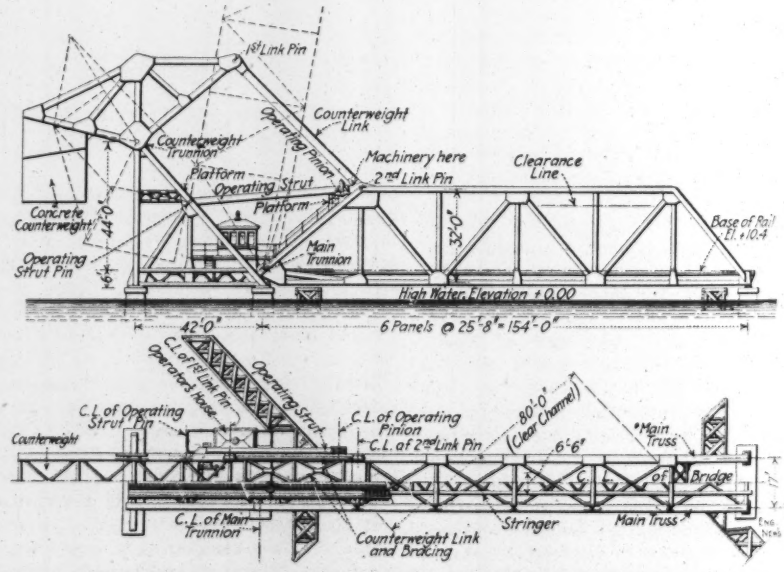


FIG. 2. OUTLINE PLAN AND ELEVATION OF DUWAMISH RIVER BRIDGE AT SEATTLE, WASH.; NORTHERN PACIFIC RY.

†See Eng. News, Nov. 24, 1904, for a description of the earliest type, represented by the Cuyahoga River bridge of the Wheeling & Lake Erie R.R., at Cleveland, Ohio.

by twelve railways; 180-ft. double-track span over the Cuyahoga River at Cleveland, Ohio, for the Erie R.R.; 152-ft. span over the Hackensack River near Rutherford, N. J., for the Erie R.R.; 186-ft. span over the Calumet River at South Chicago, Ill., for the Chicago & Western Indiana R.R.; 129½-ft. span over the Red River at Winnipeg, Man., for the National Transcontinental Ry.

Operating Mechanism

All of these bridges are operated by means of pinions located in triangular guides at the hip of each truss, which engage with cast racks bolted in the bottom of straight built-up operating struts, the ends of which carry collar bearings turning on pins attached to the inclined posts of the towers. The pinion and rack are held in mesh by the triangular guide, which is mounted on the operating-pinion shaft through bearings at the center of that leg of the triangular guide which is parallel with the center line of the operating strut. The apices of this guide carry wheels which roll along the upper and lower flanges of the operating strut.

The operating pinions are keyed to shafts which extend through the gusset plates of the trusses, and turn in collar bearings bolted to these gussets. These shafts extend toward the center line of the bridge and are connected through reduction gears to the two operating electric motors, and to each other through an equalizer. This operating machinery is located at the portal of the moving leaf, suitable girders being provided to which the motors and bearings are secured. All of the operating machinery is suitably housed and is easily accessible by means of a stairway and hand railing on the end post of the truss. In some bridges of the same type now building, the operating machinery is located on the tower, the operating strut being pivoted at the hip of the truss. These operating struts have proved entirely satisfactory in service.

The operator's house, containing the switchboard, controllers, etc., is located on brackets extending from the tower base in the Cape Cod, Duwamish River and Cuyahoga River bridges. In the Ashtabula Harbor bridge the operator is located in the interlocking tower close to the bascule. In the Peoria bridge the operator is also located in the interlocking tower, but some distance away from the bascule, as described below.

With the exception of slight deviations the several bridges are operated and controlled in the same manner.

When the bridge is closed and ready for the passage of trains, for extra precaution the leaf is locked to the piers at the front end, though there is no tendency for the live load to open the bridge. The locking mechanism as used on the Northern Pacific bridge is shown in Fig. 9, which is typical of the mechanism installed on the other bridges. It can be seen that the locking is effected by means of a latch bar located under the center line of each truss which moves in a guide attached to the bottom chord. This bar passes through rectangular slots in diaphragms between the gusset plates of the truss, and fits securely into a casting provided with a roller, permitting easy movement of the bar longitudinally, which is bolted on an extension of the bridge shoe upon which the truss rests. The locks are driven by one 3-hp. motor. Emergency hand operation is also provided.

Power is not available for opening the bridge locks until the bridge is closed to train traffic and the train signals set at danger. In like manner power for opening the bridge is not available until the locks are fully opened. This condition is brought about by connecting the lock-motor circuit and operating-motor circuit, so that the actual movement of the locks and bridge mechanically completes and breaks the respective circuits, through the medium of contact switches, in their correct order. In closing the bridge, however, power is available for holding the bridge down firmly on the seat while driving the locks. When the bridge, in opening, reaches an angle several degrees less than the total angle of opening, current supplying the operating motors is cut off automatically and the solenoid brakes on the motors are set automatically, the bridge gradually coming to rest at the correct angle of opening. A foot switch in the operator's house at the base of the controller permits the operator to release the solenoid brakes at will. Besides the solenoid brakes an emergency brake is also provided which can be instantly brought into play by the operator. A casting is also provided on the triangular operating guide, which at the extreme limit of motion comes in contact with an oak bumping block located on the operating strut at its extremity near the operating strut pin; however, these blocks seldom come into contact, as the bridge is easily kept in control by the use of the brakes. Signals indicating the successive positions of the locks and bridge proper, consisting of incandescent lamps which show through colored lenses and which light automatically when the position of the lock or bridge which they indicate is reached, are placed in the operator's house convenient to his vision. These signals are labeled corresponding to the different positions of the locks and bridge which they indicate.

An air cushion (Fig. 9) is located at the center line of the bridge attached to the front-end floor-beam. It consists of an air cylinder and piston, the rod of which strikes a plate bolted on the rest pier as the bridge closes, and compresses the air in the cylinder so as to absorb shock. The cylinder is provided with a valve capable of regulation so that the air in the cylinder can be compressed in greater or less degree, as occasion may

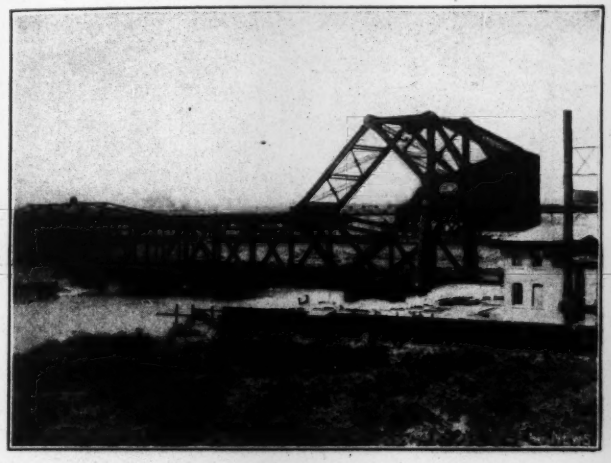


Fig. 3. Ashtabula Harbor Bridge; Lake Shore & Michigan Southern Ry.

Fig. 4. Duwamish River Bridge at Seattle, Wash.; Northern Pacific Ry.

demand. In practice the balancing of the bridge is such as to render these cylinders precautionary only.

To guide the operator in closing the span a target is attached at the end of the leaf on the lower chord and a similar target is located on the top of pier; the two halves of these targets are painted different colors, so that when the bridge is properly closed the different colored halves of each target are directly opposite each other. These targets are in plain view of the operator and serve as the most direct guide in the proper handling of the bridge. At night electric and oil lamps illuminate the targets.

As stated before, these bridges are all operated by electric power. The Cape Cod and Ashtabula bridges are equipped each with two 65-hp. d.c. motors; the Peoria bridge two 82-hp. a.c. motors; the Cuyahoga River bridge two 75-hp. a.c. motors; the Duwamish River bridge two 25-hp. d.c. motors. This power equipment was found more than adequate to operate the structures without excessive overloading under the most unfavorable conditions, namely, when the structures were first put into operation and before the gears and wearing parts had opportunity to surface themselves. About one minute is required to open or close the leaf.

Besides the electric operation employed on all of these bridges, emergency hand operation is also provided. In the Cuyahoga River bridge gasoline-engine equipment is provided as well; the engine is located in a fixed inclosure at the trunnion opposite the operator's house, and is connected to the machinery at the portal of the moving leaf by means of bevel gears and a shaft turning in bearings bolted to the outside web of the end post of the truss. When hand operation is used the motor shafts are connected to a cross shaft by means of sprocket wheels and chains, and the cross shaft has keyed to it grooved sprocket wheels which carry chains extending down to the bridge floor, furnishing a convenient means of applying power by hand. From four to eight men can be effectively employed in operating the bridge. The Red River bridge of the Transcontinental Ry. was easily operated by two men in either direction when first moved. The hand operation on these bridges is designed so that the bridge can actually be operated, in case electric power is not available, within a reasonable length of time. This mechanism on the Duwamish River bridge differs somewhat from the others, in that the shafts which carry the operating sprocket wheels also have keyed to them small pinions which engage with the same gears with which the motor pinions engage and can be disengaged when not in use.

In moving the bridge, the power applied by the operating pinion at the point of tangency with the pitch line of the operating-strut rack, acts with a leverage equal to the perpendicular distance from this pitch line to the trunnion of the moving leaf. Referring again to Fig. 1, this distance is indicated by the dotted lines x. This machinery lever arm increases as the bridge opens, which means that as a greater surface is exposed to the wind in opening the bridge the leverage through which the power acts increases. This, while of little consequence, is rather an interesting feature of the design.

In the Peoria & Pekin Union Bridge it was found advisable, in connection with the interlocking plant, to locate the operator several hundred feet distant from the bascule span in the interlocking tower at the crossing of the C. R. I. & P. Ry. In order to simplify and increase the safety of the electrical installation and operation under these conditions, the main controllers, circuit breakers, contact switches, etc., were located in a suitable fixed inclosure on the tower span of the bascule, but are operated by auxiliary controllers located in the interlocking tower. The conductors from the instruments at the command of the operator to the main equipment at the bascule span carry only very light current. The operator, instead of closing the switches and operating the controller directly by hand as when stationed right at the movable span as in the other structures, does so at a distance through the medium of the auxiliary equipment, which requires, of course, very little expenditure of power to operate. This method of operation from a distance is made possible and safe mainly on account of the accurate balance of the structure and the use of the automatic cutoffs and the check system of signals indicating the successive positions of locks and leaf, which serve as a reliable guide to the operator even though not located at the bridge itself.

Figs. 7 and 8 show the main trunnion bearing of the Duwamish River bridge. The trunnion and bearing of the Cuyahoga River bridge are similar. This detail differs from that employed in the three others, in which the tower and truss of the moving leaf are not in line; the trunnion is held in fixed bearings, one located in the base of the tower and the other on a pedestal bolted to the pier, forming fixed bearings symmetrical about the center line of the truss, the journal bearing being fixed to the truss and rotat-

FIG. 5. ERECTION OF CUYAHOGA RIVER BRIDGE AT CLEVELAND, O.; ERIE R.R.

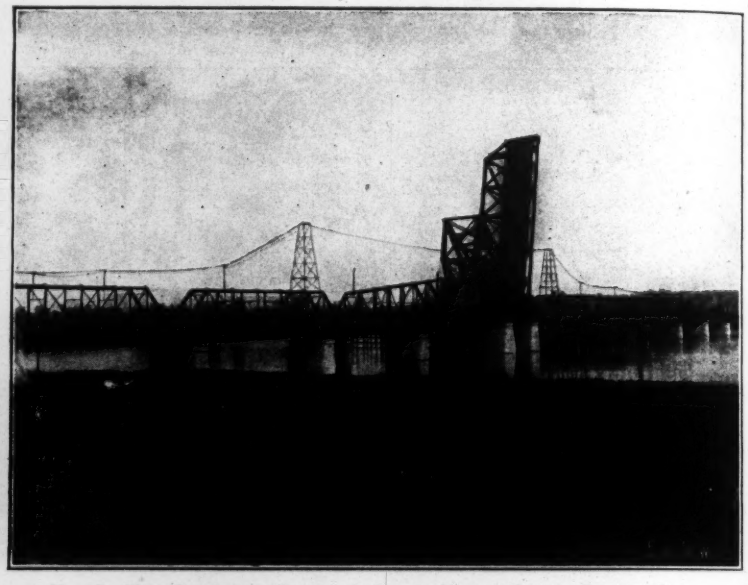


FIG. 6. NEW BRIDGE OF PEORIA & PEKIN UNION RY. AT PEORIA, ILL. (Old bridge in background.)

ing about the fixed trunnion. In the two later designs (and all subsequent structures of this type) the tower and truss are in line; the trunnion is carried by the truss and turns in the journal bearing located at the base of the tower.

The trunnion is composed of a pin made of forged steel and a cast-steel collar of considerably larger diameter; the pin, designed to take care of the bending and shear only, extends through the gusset and bearing plates of the truss, being held by Lomas nuts in the same manner as in a fixed pin-connected span.

FIG. 7. ONE OF THE MAIN TRUNNIONS, DUWAMISH RIVER BRIDGE, BEFORE ERECTION OF TRUSS

The cast-steel collar, which turns in the phosphor-bronze bushing of the journal bearing, is made of sufficient diameter to provide ample bearing surface and permit of relative motion with very little friction. This collar also furnishes a convenient and effective means of securing the trunnion to the truss, by a circular series of bolts extending through the collar and the gusset and reinforcing plates of the truss. The counterweight trunnion and bearing at the apex of the tower are detailed in a similar manner.

The advantages over the original design gained by arranging the towers in line with the trusses are as follows: Both the main trunnion and counterweight trunnions are less than half as long as in the original design; the bending moment is reduced to a minimum; both inside trunnion pedestals are dispensed with; and the distance center to center of tower posts is reduced about 5½ ft., thereby effecting a considerable saving both in the piers and the superstructure of the tower.

Since the trunnions are located directly at the pier tops, the points of resistance to lateral stresses are practically at the pier tops, giving maximum stability. This lateral stiffness insures quite perfect alignment of the trusses, and, though the bridge-seat castings on the front pier are provided with guides on the outer edges which extend upward and outward from the top surface of the seats, these guides seldom come into action.

The counterweight proper is composed of concrete, and on all but the Duwamish River and Cuyahoga River bridges is held in a structural-steel box riveted to the counterweight frame. In the latter the box is omitted, the concrete counterweight being thoroughly reinforced so that it is self-sustaining. Pockets are left in the counterweight so that weights can be added or deducted and a perfect balance obtained.

All parts of the bridge are thoroughly braced, the moving leaf in this respect being no different from a fixed simple span (and under live load it acts as such). The counterweight tower has stiff portal braces both in the planes of the inclined and vertical posts, and the vertical posts are braced laterally by inclined members which extend from the counterweight pin down to reinforced-concrete brackets on either end of the counterweight pier. The counterweight trusses are braced together by means of struts and diagonals, and the same is true of the counterweight links.

The Cape Cod, Ashtabula and Duwamish bridges were erected in the closed position. The Peoria and Cuyahoga bridges were erected in the open position, thereby maintaining an open channel and in no way interfering with navigation at any time.

In the Cuyahoga River bridge it was found necessary to maintain railway traffic as well as river traffic. In order to accomplish this, provision was made in the design so that with the bridge open the lowest point of the counterweight would not encroach on the standard railway clearance. The old swing bridge was rest pier of the swing. The latter was removed on completion of the new bridge.

The performance of these bridges in actual service has been satisfactory, and they have all given an excellent account of themselves for swift and noiseless operation and dependability.

The bridge engineers under whose direction these bridges were designed, fabricated and erected were: W. H. Moore, Bridge Engineer, N. Y., N. H. & H. R.R. Co.; B. R. Leffler, Bridge Engineer, Lake Shore & Michigan Southern

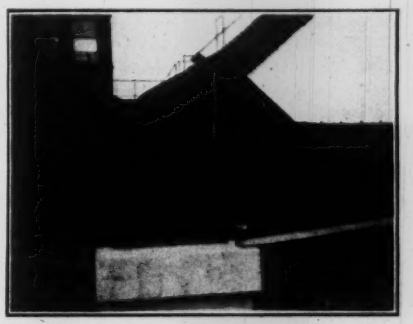


FIG. 8. TRUSS SEATED IN TRUNNION, DUWAMISH RIVER BRIDGE

Ry.; Walter E. Emery, Chief Engineer, P. & P. U. Ry., with J. E. Greiner acting as Consulting Engineer; H. E. Stevens, Bridge Engineer, Northern Pacific Ry. Co.; and F. A. Howard, Bridge Engineer, Erie R.R. Co. The McClintic-Marshall Construction Co. built the P. & P. U. Ry. bridge, the American Bridge Co. built the Northern Pacific, and the Pennsylvania Steel Co. built the Cape Cod, Ashtabula and Cuyahoga River bridges.

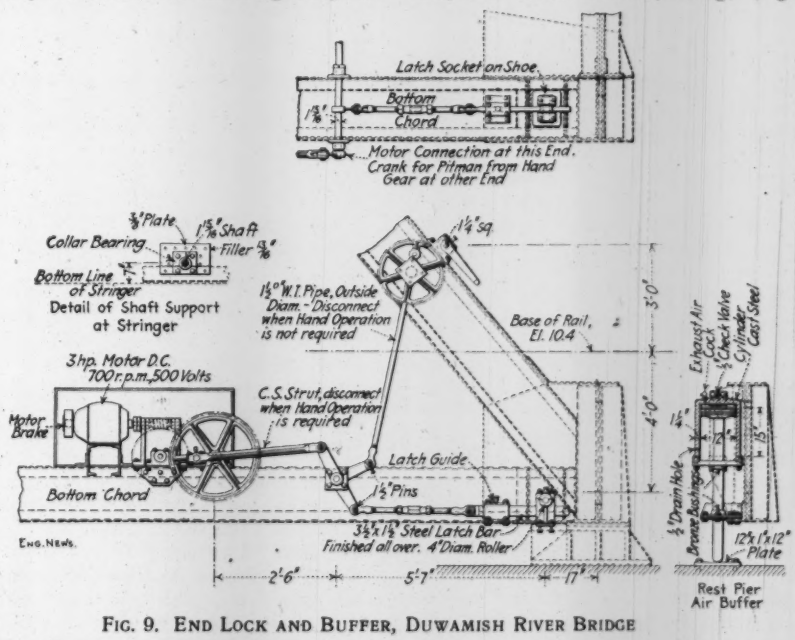


FIG. 9. END LOCK AND BUFFER, DUWAMISH RIVER BRIDGE

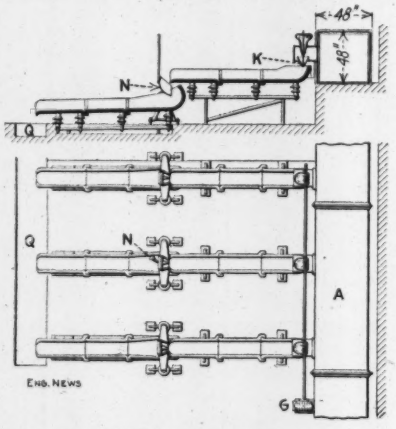
220 ft. in length, giving two narrow channels. The new structure was so located that the old pivot pier with modifications could be utilized for the rest pier of the bascule, and, the new span being 180 ft. in length, the new trunnion and counterweight piers were built clear of the old

An Automatic Water Rheostat for Absorbing Excess Coasting Energy in a Three-Phase Railway

On the new three-phase Giovi Ry., in Italy, a line having long and steep gradients, the recovery of energy in the coasting of trains is a material element of operation. On account of the small density of traffic, it may often occur that a train going downhill returns more energy than is required at that moment by other trains on the line, even making allowance for the energy required to keep the power-house machinery running idle. To meet this condition a large water rheostat has been installed in the Chiappella power house, automatically controlled in such manner as to go into action whenever the incoming power exceeds the outgoing, and go out of operation when the balance turns the other way. The apparatus is described and illustrated in "L'Ingegneria Ferroviaria" of Feb. 15, 1912.

The outflow from the steam condenser is used as the water supply for the rheostat. The discharge flows through a rectangular steel conduit *A*, shown at the right in the sketch herewith. A gate at the end of this conduit permits regulating the outflow in such a way as to maintain any desired minimum depth of water in the conduit. Three nipples attached to the side wall of the conduit contain conical valves *K*, which, when open, allow the water to flow out and into the rheostat containers. These containers, three in number, consist each of two troughs in series; the troughs are of earthenware and are supported on insulators. The water entering the upper trough of a set flows down in a narrow solid stream, and at the end of the trough strikes a curved metal deflector plate *N*, which guides it into the upcurved or hood-shaped head of the lower trough. At the far end of the lower trough it flows into the waste channel *O*. The three deflector plates *N* are connected to the three phases of the busbars. When water is flowing through the rheostat troughs, the three deflector plates are connected by two sets of water conductors in parallel by way of the condenser conduit *A* and the waste channel *Q*.

The valves *K* are actuated by worm gearing from a small motor *G*, started, stopped or reversed by a relay. This relay is controlled in series by the governor and the steam valves of the steam turbine which drives the generators. When the turbine is in motion, but is not drawing steam, that is, when it is running idle, the relay closes a circuit which supplies current to the small motor *G* and sets the water rheostat in action As a result, an artificial load is put on the system, which absorbs the incoming excess power and in addition loads the generators slightly, so that the steam valves of the turbine open. When the turbines are again taking steam, the relay contact opens and simultaneously



AUTOMATIC WATER RHEOSTAT FOR CONSUMING EXCESS ENERGY, CHIAPPELLA POWER-HOUSE OF GIOVI RAILWAY

establishes a reverse circuit, which starts motor *G* running backward, thereby tending to close the water valves and reduce the load by lessening the cross-section of the water path in the rheostat. Thus a balance is maintained between the amount of energy which must be dissipated and the amount consumed in the rheostat. The effect is to keep the generator always under a slight load, whereby it is prevented from operating as motor.

This rheostat is said to have a capacity of 5000 kw., which is far greater than that will ever be required in the station.

Classified Distribution of Salaries and Wages of the City Employees of Chicago

As a part of what appears to be an exhaustive analytical study of the compensation and classification of the employees of the City of Chicago, the Civil Service Commission of Chicago has had made a number of interesting tables and charts. Through the courtesy of J. L. Jacobs, in charge of the Technical Section, Efficiency Division, of the commission, we are enabled to reproduce one of the charts and one of the tables.

The item "Miscellaneous," in the middle pair of diagrams, includes, among other employees, 115 positions under special park commissions, 54 in the municipal tuberculosis sanatorium and 34 in the smoke-inspection department.

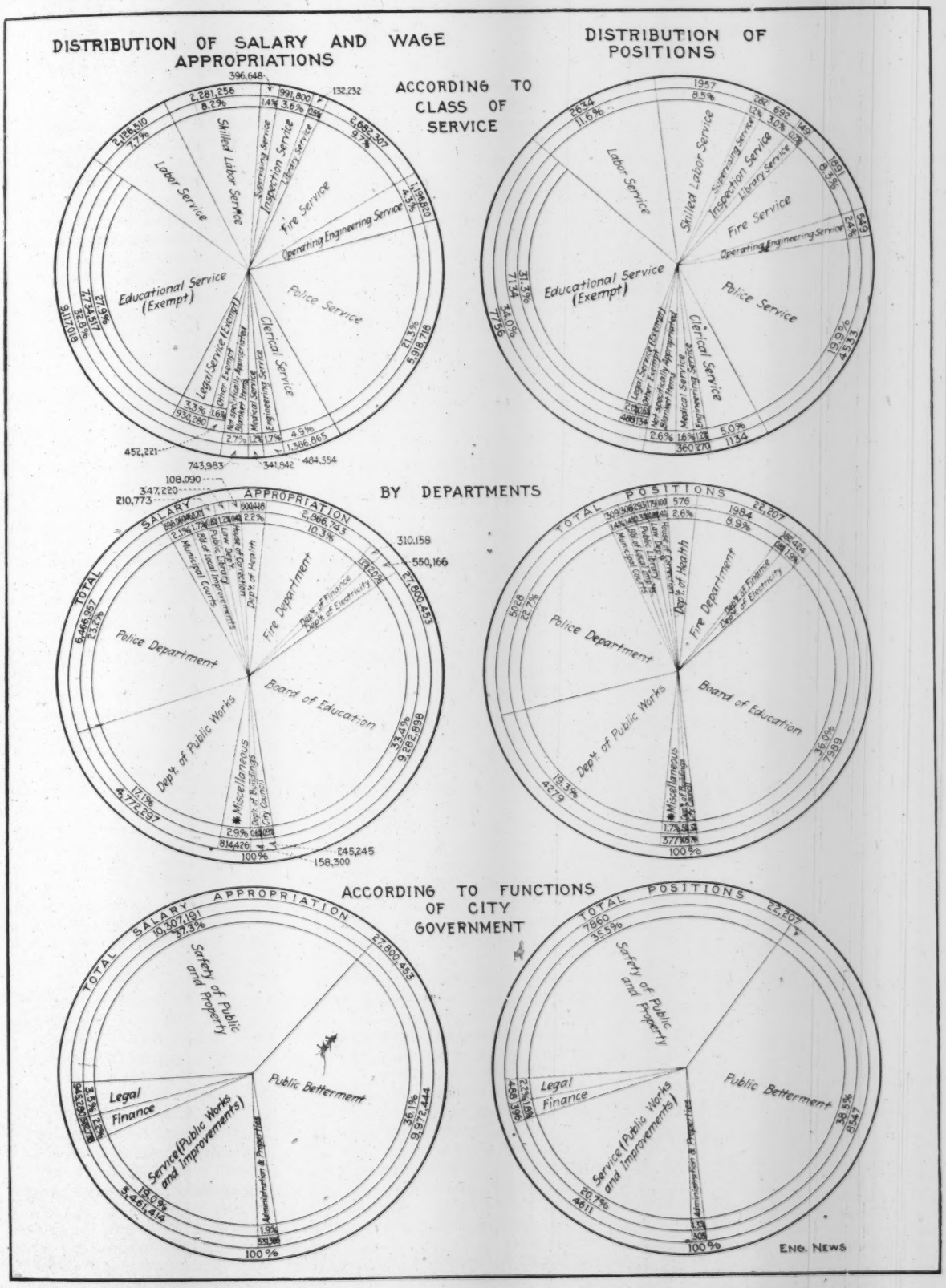
Of the grand totals of 22,207 positions and $27,800,453 wages, 14,451 positions and $18,683,435 wages come under the city civil service.

The results of the whole study, which will be published by the commission in due time, is one of many evidences of an awakening and intelligent interest in questions of municipal efficiency.

POSITIONS IN THE ENGINEERING SERVICE—CLASS "B"

Distribution and Compensation, City of Chicago, 1912

	Number of Positions	Average salaries
Assistant architectural draftsman	8	$1167.00
Draftsman	9	1187.00
Laboratory engineering assistant	3	1080.00
Map draftsman	19	1161.00
Rodman	41	1116.00
Totals and average, grade I	90	1131.00
Architectural draftsman	10	1566.80
Assistant engineering chemist	6	1500.00
Clerk of the works	5	1500.00
Electrical engineer	1	1620.00
Engineering draftsman	11	1535.00
Junior engineer	31	1521.00
Map engineering draftsman	9	1487.00
Mechanical engineering draftsman	12	1519.00
Plan examiner	2	1830.00
Title searcher	2	1800.00
Totals and average, grade II	89	1535.00
Architectural designer	6	2093.33
Architectural engineer	8	2220.00
Assistant engineer	24⅓	2102.00
Assistant superintendent of construction	4	2600.00
Bridge designing engineer	3	1788.00
Building inspector in charge	1	2500.00
Chief draftsman, maps and plats	1	1740.00
City forester	1	2000.00
Deputy smoke inspector in charge	1	1800.00
Designing engineer	1	1794.00
Electrical designing engineer	1	2400.00
Engineering chemist	2	1960.00
Examiner of efficiency (technical)	3	1920.00
Expert asphalt chemist	1	2400.00
Heating and ventilating designing engineer	1	2400.00
Mechanical designing engineer	2	1800.00
Sanitary designing engineer	1	1920.00
Totals and average, grade III	61⅓	2111.00
Assistant chief engineer, sewers	1	2700.00
Assistant chief engineer, streets	1	2700.00
Chief architectural designer	1	3600.00
Chief deputy smoke inspector	1	3000.00
Chief street engineer	1	3600.00
City architect	1	4500.00
Deputy commissioner of buildings	1	4000.00
Engineer (harbor, wharves and bridges)	⅓	3000.00
Engineer in charge of bridges	1	5000.00
Engineer of bridge construction and repairs	1	3000.00
Engineer of bridge design	1	3600.00
Engineer of tests	1	3000.00
Engineer of track elevation	1	4200.00
Engineer of water surveys	2	3000.00
Engineer of water works construction	1	4000.00
Engineer of water works design	1	3600.00
Expert on system and organization	1	3000.00
Mechanical engineer in charge	1	7500.00
Secretary and engineer	1	3600.00
Superintendent of construction	1	3200.00
Superintendent, maps and plats	1	4000.00
Superintendent, water pipe extension	1	4500.00
Supervisor mechanical engineer and chief deputy inspector	1	3000.00
Third assistant superintendent of streets in charge of street repairs	1	3600.00
Totals and average, grade IV	24⅓	3695.00
Architect, board of education	1	6000.00
Assistant architect, board of education	1	4000.00
Assistant city engineer	1	5000.00
City engineer	1	8000.00
Engineer, board of local improvements	1	3600.00
Totals and average, grade V	5	5320.00
Total number of positions		270
Total salaries		$484,354
Average salaries		$1796



DISTRIBUTION OF SALARY AND WAGE APPROPRIATIONS AND OF POSITIONS AT CHICAGO 1912

Unwatering an Old British Copper Mine*

By Cyril Brackenbury†

Tresavean is a famous old Cornish mine which, during the first half of the 19th century, held an important position in Great Britain as a copper mine. In the early fifties the lode was becoming poor in copper and expensive to work with the plant then in use.

It had not yet been recognized that good copper lodes in Cornwall often turn to good tin lodes as depth is attained, so that though a good deal of tin was discovered in the lower workings no one thought much about it. Finally, in 1857, owing to a dispute between the landlord and mine owners and the rea sons given above, the pumps were drawn up and the mine allowed to fill with water.

When the present company acquired the mine in 1907, it was decided to unwater the mine by means of temporary electrical pumps, to be replaced by permanent electrical pumps later, rather than by installing a Cornish pumping plant. The important advantages of this method were, that by putting in an electrical power-generating plant, the extra power available after completing the unwatering could be conveniently used for milling, winding, or any other purposes required about the mine, and one good central power plant could be run more economically and efficiently than several smaller independent plants scattered about the property.

The unwatering has now been successfully carried out by means of electrical high-lift turbine pumps, in spite of serious obstacles, to beneath the 1488-ft. level below adit, which is, I believe, the largest and most successful operation of the kind yet achieved in the county with an electrical plant. Up to the present date, eight such pumps have been used in the work, but never more than three have been worked together at the same time, the others merely acting as reserves.

Six of the pumps are designed for a delivery of 600 gal.* per min. through a lift of 600 ft., when running at a normal speed of 1450 r.p.m. An extra 60 ft. head is allowed for suction lift and friction head. Three of the pumps of the vertical type are used for sinking purposes and five of the horizontal type are used as station pumps.

Each pump has a throttle valve attached to regulate the discharge, and immediately above this there is fitted a check valve to support the weight of water contained in the rising main when the flow of water ceases for any cause. Similar check valves are placed in the rising main at distances apart of about 240 ft.

Each combined set consists of pump and motor, bolted to the same bed plate in the case of the horizontal pumps, and to the same channel iron frame in the case of the sinking pumps. The motors for the vertical pumps are of the inclosed three-phase alternating current type, water-cooled, and ventilated internally by means of a revolving fan attached to the rotor shaft and designed to develop 190 b.hp.

When the writer first came to the mine he found one of the two shafts an inverted cone-shaped excavation 40 ft. in diam. at the surface, tapering down to the dimensions of the shaft, where the first solid choke began, at about 46 ft. below the surface. The necessary timbers were put across this hole, a windlass set up and the work of clearing begun.

Good solid rock was found about 40 ft. below surface, and the first set of shaft bearers was put in at 46 ft. from the top. The shaft was evidently about 12x6 ft. within the old timbers, and it was decided to make the new shaft in three compartments, two of them 6x4 ft. within timbers, and the third compartment at the end 6x3 ft.

The top frame sets were all made of 8x8-in. pine timbers with beveled miter joints; dividers 6x8-in., with dovetailed ends, are mortised into the wall plates; the studdles are 6x8-in., and the corner posts 8x8-in., outside lagging 2 in. thick. The shaft timbering was designed with the object of first suiting unwatering operations, and afterwards permanent working conditions. The two large compartments were first arranged to each take one of the sinking pumps with all the necessary cables, tackle, etc., as well as the temporary 6-in. rising main. The third compartment is at present divideu into two parts, one for the skip or man cage, the other for the ladder way.

After the unwatering is finished and the proper hoisting arrangement has been installed in the two large compartments the small skipway will no longer be required, and the whole third compartment, can be used for the ladder way and permanent rising main.

The regular timber sets with 2-in. lagging are only carried up to about 17 ft. below the timber collar at surface, the intervening space being entirely secured by a 2-ft. concrete lining, in which 6x8-in. dividers and end pieces are set to carry the necessary guide rods. The opening between the concrete wall and the old sides of the cone-shaped hollow was carefully filled and rammed. The headgear foundation was built up of reinforced concrete resting on rough masonry.

The headgear was designed with a view to making it amply strong and suitable for the double purpose, first for unwatering operations, and afterwards for regular mining work. The pump pulleys were fixed at 42 ft., the temporary skipway pulley at 58½ ft., and the regular winding pulleys at 60 ft. above shaft collar. The opening left for the sinking pumps was 36 ft. high.

The shaft was cleared, secured and equipped down to adit level and the headgear erected long before the pumping plant was ready to start operations. The work of the first 80 ft. or so below surface was carried out with an ordinary hand windlass and bucket, and from this depth to water level, 150 ft. below surface, the work was carried out with the help of a small steam winch and tip bucket.

The adit level was opened at a depth of 147 ft. below top of shaft collar, and the station was enlarged here to take two V-notch delivery tanks, each fitted with a patent water recorder. Down to this point the work was easy and plain sailing, in spite of the large excavation at surface and solid choke extending from 46 ft. downwards. The shaft was cleared and secured from surface to adit in about three months' time.

Regular pumping began Apr. 26, 1909, and the 162-ft. level was not reached until Aug. 9, the slow rate of progress being due to great difficulties with the chokes. The pumps were not designed to handle the broken rock, gravel, crushed timber, and grit found in all the chokes, and we were obliged to resort to special means to safeguard and spare the sinking pump as much as possible.

The best way out of the difficulties was by getting the suction down through holes in the chokes, whenever we could, into clearer water below, or by putting our suction pipe down in the old pump column, which was still standing in place in the shaft. In the latter case it was occasionally necessary to blast out the sides of the old column to let in the water, after having first secured it firmly with chains and timber.

Near the doors of the 162-ft. level we resorted to a method which has since been found most satisfactory for all deep solid chokes. The method consists in substituting for an ordinary suction pipe a special one with a sharp point at the lower end, to enable it to be driven down through the choke, and with a connection at the upper end to which a special valve box containing a strainer can be fitted. The conical point is made of mild steel, and can be welded on or screwed to the lower end of suction pipe.

In the first instance this method was used to pump through a choke only a few feet thick resting on doors at the 162-ft. level, and the steel-pointed pipe was easily driven down through some 8

*Brief abstract of a paper read at a meeting of the Institution of Mining and Metallurgy, London, England, Jan. 18, 1912.

†M. Inst. M. M., Benwell, Newcastle-upon-Tyne.

*Imperial gallons.

ft. of débris and through the wooden doors which were supporting it. After having driven the end of the pipe a few feet below the platform, the point was blasted off, the upper end was connected through the valve box to the suction end of the pump. The special suction pipe used was of 4-in. diam., and the pump worked very satisfactorily with this arrangement, keeping the water well down below the top of the choke and enabling the men to conveniently clear it away.

In one of the four other mines using high-lift turbine pumps for unwatering purposes, the pump was slung by a four-fold rope system and in three cases by a two-fold rope system. The four-fold system requires two pulleys on each pump and two pulleys for each pump on the head-gear; the two-fold system requires only one pulley on each pump and one pulley for each pump on the head-gear.

We decided to use a single fall larger rope attached to a pair of triangular plates carrying a two-fold rope sling passing round the pulley wheel of pump. The single fall of rope, although double the strength, has, of course, only to be half the length of a two-fold rope, and, consequently, there is only half the length to be looked after and greased. The short sling, which is of just sufficient length to clear comfortably the bend of delivery pipe, makes a convenient way of supporting the pump frame without straining it.

Taking into consideration the comparatively great depth the water would have to be lowered, we decided to support the rising main along the walls of the shaft, connecting the bottom of it by means of a short reverse bend with the top of pump delivery, a telescopic expansion joint being inserted above the top of pump delivery and just below the bend to rising main. We further decided that the pump should always be supported by chains as well as by the rope, except when it was actually being lowered or raised in the shaft.

In order that the weight of the pump should be taken up quickly and conveniently, two adjustable stretching screws were obtained for each pump, and ¾-in. short link chains were made in lengths of 25 ft. and 9 ft., each chain having a large hook at one end and a large link at the other end The 9-ft lengths were made with large links set about the same distance apart as the adjusting length of each stretching screw.

Each tightening screw is shackled to the eye at the top of each of two steel plates, which are securely bolted to the two channel irons of the pump frame. Two sets of chains are attached to each pump, and these are sufficiently strong to carry the full weight of pump and water column in the rising main, but the chains are never tightened so as to take the full weight, but only sufficiently to take the greatest strain off the supporting ropes. Each time the pump is lowered it only takes a few minutes to hang the new chains and tighten them up to the proper position.

The rising main used for unwatering operations is a 6-in. internal diam. lap-welded steel pipe with loose Albion flange joints packed with a single rubber washer. The regular length of each pipe is 18 ft., but a few lengths of 9 ft., 6 ft., 4 ft., 3 ft., 2 ft., and 1 ft. are used as a convenience when occasion requires it.

There are two independent 6-in. rising mains fixed in the shaft from the adit to the 450-ft. level, one in each pumping compartment, but below the 450-ft. level there is only one. It was originally intended to use two pumps and two rising mains in the shaft while unwatering down to the 1200-ft. level, but it was soon found by experience that the old pit work would seriously interfere and, owing to the very confined space in the shaft, it was never found advantageous to lower the two sinking pumps at the same time.

In the case of dealing with small chokes under water various forms of hooks and grabs, on long handles made of ¾-in. to 1¼-in. round iron, were used, also a kind of iron scissors for lifting large rocks or timbers from under water. A drop-screw was used more than once in the work of dismantling and taking up the weight of the old pit work. A large steel-pointed harpoon and heavy iron rammer were both tried, in the way of breaking through and penetrating chokes, but this method of attack was not found satisfactory.

In the worst place of the shaft, that is, above the 1272-ft. level, where the ground is badly disturbed by a cross-course, it was found advantageous to drive in a few rows of pointed iron rods from 5 ft. to 9 ft. long. Each row was put in just above the last end-piece of a set after it had been firmly secured. The rods were placed about 8 in. apart and driven in their full length, inclined slightly upwards. This method, together with ordinary wooden spills driven down the sides as the choke was cleared, was found to answer very well, and prevented further heavy runs of loose ground into the shaft, as had occurred when the spilling method had been used without the addition of these iron rods.

The object of using iron rods instead of ordinary wooden spills was two-fold; firstly, because the rods placed horizontally took up so little room, that the nearly vertical timber spills could still be conveniently driven downward between them; secondly, because wooden spills were not strong enough for the work, and could not be successfully driven horizontally through the mixture of loose decomposed granite containing hard boulders.

In a few places in the shaft it was found possible to make use of some of the old timber sets, usually about 9 in. by 8 in. cross-section, also a little of the old lagging, but as a rule it was found to be broken or too rotten for our purpose. For only very short distances have the walls of the shaft been found sufficiently strong to stand safely without close lagging.

The author believes there are still several old mines in Cornwall well worth unwatering and reopening, and for this reason the question of the most suitable system of pumping for unwatering purposes is of particular interest. In some cases, where an old mine is to be unwatered and there appears to be no suitable shaft for the purpose, it might be advisable to sink an entirely new shaft clear of the old workings and cross-cut back to them, after having installed the necessary pumping plant. But where it is decided to make use of an old shaft 600 ft. or more in depth below adit, and to use the electrical system of pumping, the author would recommend that special attention be paid to the following points:—

(1) No effort and expense should be spared in clearing and securing all adits as quickly as possible.

(2) Centrifugal pumps should be of such a type that the separate stages can be easily removed and added as required, and the pumps so arranged that the stages can be added and all ordinary repairs conveniently carried out down in the shaft.

(3) The rising main should be secured to the shaft instead of being carried on top of the pump.

(4) Small removable strainers should be placed on the pump fittings to prevent the water-cooling pipes round the bearings from becoming choked. The water-cooling pipes should be made of copper to prevent corrosion.

(5) At the bottom of the suction pipe a copper strainer should be used, of ample superficial area, with small openings.

(6) Duplicate pumps should be available, both for sinking and station purposes, so that there may always be a spare pump to fall back upon when either a sinking pump or a station pump is undergoing extensive repairs.

(7) Ordinary spare parts for repairs and renewals should be made interchangeable between all station pumps, and all sinking pumps, and where possible also between station pumps and sinking pumps. In the case of badly acid water the inside body of the pump should be made of gun-metal or some other metal suitable for resisting the corrosive action of the water.

A New Railway Route from Chicago and St. Louis to New Orleans

With the completion of the Panama Canal (which is now practically in sight), there will be a development in the commerce of the Gulf ports, and a consequent increase in the traffic of north and south railways having terminals at these ports. Improvements have been undertaken already by some of these lines, and some new routes are being developed by railways desirous of obtaining a share of the traffic.

Prominent among these new developments is the work of the "Frisco Lines" in securing access to the ports of New Orleans and Mobile by means of direct lines from Chicago, St. Louis and Kansas City. Hitherto, this system has had no through line of its own to the Gulf coast, although it has a coast line running west from New Orleans. The new line, therefore, will open a new through route from the Central states and the Southwest to two important Gulf ports. Some new construction is required in completing connecting links, and the most important work will be a new bridge over the Ohio River, as noted below. In addition to this, there will be required a considerable amount of improvement work to make some parts of the existing lines suitable for fast service and heavy traffic. For maps and information respecting this important railway development we are indebted to B. L. Winchell, president of the Frisco Lines. The new route and its principal connections are shown on the accompanying map, which shows also the main lines of the Illinois Central R.R. to New Orleans.

The Chicago & Eastern Illinois R.R. (Frisco Lines) has a direct line from Chicago to Joppa, Ill. (which is close to the Ohio River), a distance of 363 miles; it has also a direct line from Chicago to St. Louis. The former line has a branch to the Mississippi River, connecting with a river line of the St. Louis & San Francisco R.R. (Frisco Lines), so that Joppa is the meeting point of routes from both Chicago and St. Louis to the South. A railway will be built from Joppa, Ill., to Paducah, Ky., crossing the Ohio River at Metropolis, Ill., a few miles below Paducah. No details of the bridge are available as yet, but (as noted in our issue of Mar. 21) it is estimated to cost about $3,600,000, or $4,500,000 including approaches.

From Paducah, the route will be over the Nashville, Chattanooga & St. Louis Ry., which at Jackson, Tenn. (144 miles), crosses an extension now being built from Middleton, as shown. However, a new and more direct connecting line will be built from some point on the N., C. & St. L. R.R. to the N. O., M. & C. Ry. at Jackson or Middleton, and surveys are now being made for this connection, two approximate routes for which are indicated by dotted lines. South of Middleton the route is over the New Orleans, Mobile & Chicago Ry., a new line which is controlled jointly by the Frisco Lines and the Louisville & Nashville R.R. This has its own line into Mobile, while New Orleans is reached by means of a track-

MAP OF THE NEW LINE OF THE "FRISCO SYSTEM" FROM CHICAGO (AND OTHER POINTS) TO NEW ORLEANS AND MOBILE

age agreement over 146 miles of the New Orleans & Northeastern Ry., from Laurel, Miss. From Middleton the distance is 258 miles to Laurel and 370 miles to Mobile.

The Kansas City route will be by way of the Frisco Line now extending through Memphis, Tenn., to Birmingham, Ala., and which crosses the N. O., M. & C. Ry. at New Albany, Miss. The through routes will be about 950 miles from Chicago to New Orleans, and 920 miles from Kansas City to New Orleans.

Report on the Water Purification Plant of Quincy, Ill.

A new mechanical filtration plant for Quincy, Ill., a change from sulphate of iron and lime to sulphate of alumina as a coagulant, the use of hypochlorite of lime as a disinfectant, a new, large and better designed sedimentation chamber, the installation of at least one Venturi meter or some other means of determining the amount of water filtered, duplicate high- and low-duty pumps, the substitution of gate valves for check valves to control connections between the company's water supply and private systems supplied with impure water, and thorough and frequent dairy and milk-supply inspections by the city have been recommended by Charles A. Jennings, a sanitary chemist of Chicago, in a report recently made by him to the city council of Quincy. The mechanical filters, of the Jewell type, were installed some 20 years ago and are in need of repairs. The average bacterial removal effected by the filters (and sedimentation basin?) from October, 1911, to Feb. 9, 1912, averaged 86.2, with a minimum of 54.6% and a maximum of 98.5%. The poor results obtained are ascribed to: the sedimentation basin being only one-third the needed size and not being properly baffled; the character of the coagulation prior to filtration; the large size of the grains of the filter sand, due to incrustation; and the varying rates of filtration, which are often excessive; and to the disrepair of the filters and possible contamination from leaky wash-water pipes.

The character of the chemical treatment, as summarized in a copy of the Quincy *Journal*, of Mar. 5, 1912, sent to us by Mr. Jennings, is as follows:

> The chemical treatment plant consists of a two-story building, the upper floor of which is used for storage of chemicals and for preparing the solutions and the lower floor contains two tanks each 10 ft. deep and 11 ft. 10 in. in diameter, of 6365 gal. capacity, for lime solution and one tank 6 ft. deep and of 3525 gal. capacity for sulphate of iron and lime solutions, the regulating valves and a lime pump. Under the present method of operation a solution of sulphate of iron is fed direct from the tank into the suction pipe of the low-duty pump, the flow being controlled by means of a valve with a lever attached to it. A saturated solution of lime is pumped from one of the two lime tanks to the fore bay or inlet to the sedimentation basin and discharged into the water from the low-service pump, previously impregnated with sulphate of iron solution. This produces a coagulation similar in appearance and purposes to that propuced by the white of an egg in coffee.

The two lime and the one iron sulphate solution tanks are in bad condition and likely to leak at any time.

Considerable difficulty has been experienced with the pipe which conveys the water from the settling basin to the filters due to the incrustation of calcium carbonate, which forms on the inner surface of the pipe as a result of the use of lime in the coagulating process. At one time the pipe that supplied the filters was entirely choked up. The pipe affected had to be cut out. The newer filters give the highest percentage removal of bacteria. Quincy is not the only city that has had this experience with incrustation. Danville and Moline as well as other cities have had trouble.

The sedimentation basin gives only one hour's detention to the water. The size of the filter sand has been increased by incrustation caused by the "calcium corbonate deposits, due to the sulphate of iron and lime treatment."

At present Quincy has no milk or dairy inspection. In some cases, water cisterns and privies are almost within reaching distance of each other. These conditions, as well as the use of check valves instead of gate valves to separate interconnected water-company mains and private water mains demand the early attention of the city.

Fortunately, Quincy is a long distance below any city using the Mississippi for sewage disposal. The bacterial count of water at the Quincy intake crib was 116,000 on Feb. 7 and 174,000 at the suction well. The intake is of banded wood-stave pipe, but no conclusive evidence of leakage is given in the report. It should be added that after filtration the water goes to a reservoir having a capacity equal to about eight days' consumption.

Some Opinions on the Principles Which Should Govern Water Pollution

In the hope of helping a crystallization of opinion regarding water pollution by sewage and manufacturing wastes, Paul Hansen* recently sent a list of questions to 120 sanitary officers, engineers, chemists and bacteriologists, asking their conception of the principles that should govern sewage disposal and water supply in relation to water pollution. Of those heard from, 51 answered the questions directly, 8 sent general statements and about a dozen declined to reply. In March, 1912, Mr. Hansen presented to the Illinois Society of Engineers and Surveyors a classified digest of the replies just mentioned. Extracts from some of the replies were given, together with what Mr. Hansen considered to be the consensus of opinion on the positive and negative sides of the questions formulated by him. The identity of the authors of these extracts from the replies was not disclosed, but a list of those who responded to the inquiry was given. The list included a considerable number of well known public-health officials, as well as engineers, chemists and bacteriologists.

Mr. Hansen's paper merits reading in its entirety, but as it would fill many pages of this journal, those interested must await the publication of the *Proceedings* of the society named above. Mr. Hansen's summary is as follows:

"A summary of the foregoing must consist largely of the writer's own opinion formed in the light of the various responses. It was pointed out in the very beginning of the paper that such a compilation as is herewith presented cannot be expected to result in a statement that all sanitarians can accept, nor does the writer desire what follows to be considered a final unchangeable opinion of his own views. The hope has been entertained, however, that a compilation such as this will be of value in giving some definite nucleus to what has hitherto been an incoherent mass of varying and conflicting ideas. Once the nucleus has been formed it may be built up in the light of experience until there has been accumulated a body of reliable opinion that will explain clearly the position of the sanitarian to the public.

"What is said throughout the paper applies purely to general principles and not to ways and means for solving specific problems. It will always be necessary to have the services of experts to decide how many gallons and what kinds of wastes may be discharged into a stream to keep within the limits of a desired result; the methods that are best adapted to treating sewage and other wastes, the best methods of purifying water supplies taken from surface streams and many other technical matters of vital importance. But the public must be made familiar with the general principles that govern if our movement for clean streams is to be effective, consistent, rapid and economical.

"In the writer's opinion, as molded by the responses, there are a few fundamental propositions to which sanitarians may generally agree. They are as follows:

"(1) No stream, unless the entire watershed is owned or controlled, can be maintained in its original and natural purity.

"(2) Streams may be, and should be, maintained free from danger to the public health, inoffensive to a proper public sense of decency and beyond this they should be controlled so as to contribute the greatest serviceableness to the public at large. Within these limits it is permissible to discharge any liquid wastes into streams; local conditions to control in every instance.

"(3) Public water supplies may be drawn from moderately polluted streams, provided the supply is adequately purified to prevent danger to health. The extent of pollution permissible under these conditions should be determined by the limitations imposed by the art of water purification and to some extent by purely esthetic considerations.

"(4) The desirability of maintaining fish life in streams is largely an economic problem, though in the case of streams along which fishing industries are established prior right should be considered a basis for preventing pollution dangerous to fish life or for awarding damages. The presence or absence and character of fish life may under some circumstances serve as an index of the extent of pollution.

"(5) Stream pollution is primarily a menace to human health through domestic water supplies which may be drawn from polluted streams, but there are various other dangers to health, prominent among which are bathing and shell-fish pollution, which should be duly recognized in considering any specific problem.

"(6) While the determination of permissible stream pollution must depend primarily on public-health considerations and, secondarily, on economic considerations, esthetic considerations and civic decency must always be factors and many times the controlling factors.

"(7) Control of stream pollution by laws defining specifically the extent to which streams may be polluted and enforced by the ordinary police power is unwieldy, unwise and unjust. Instead the laws should be made very general and their enforcement placed in the hands of a central expert authority as interpretor of the laws in the light of local conditions. To guard against abuse it should be made easy to appeal from decisions of the central authority to an impartial commission of experts and finally to the courts.

"(8) In the United States the pollution of *intra*state streams should be under state control and *inter*state streams should be under federal control. Since from an economic and engineering point of view control by drainage boards over complete drainage areas is the logical and efficient form of control, it should be adopted wherever conditions permit, but with the present form of government it is not believed to be of universal applicability."

*Engineer, Illinois Water Survey, Urbana, Ill.; lately State Sanitary Engineer, Kentucky, and earlier on the engineering staff of the Ohio Board of Health.

Draining the Miami Canal on the six miles of its length in Cincinnati, and utilizing its channel and right-of-way as a route for bringing several interurban electric railways into the heart of the city is seriously proposed. At the request of the city authorities the Ohio legislature passed a bill authorizing the city to drain the canal and lease its bed. A commission has been appointed to study the matter, and to negotiate with the railway companies interested. Its report will be made to the mayor and the council. Dr. Herman Schneider, of the University of Cincinnati, is at the head of this commission.

Constructing a Concrete Pile Foundation

The sketch plan Fig. 1 herewith shows a large foundation of concrete piles put in at Pittsburg recently. The foundation is for a warehouse building for the Alling & Cory Co., paper manufacturers, at River Ave. and Balkum St., North Side (Allegheny). The soil is soft enough to require piling for the heavy load of the building, and the architect therefore chose a foundation of reinforced-concrete slab footings resting on concrete piles. The unusual form of pile grouping is the design of R. A. Cummings, specialist in reinforced concrete, Commonwealth Building, Pittsburg.

The soil at the site of the warehouse includes a top layer of fill, varying from 5 to 10 ft. deep, below this 15 to 20 ft. of river clay with sand, and below this again coarse gravel. The pile foundation transfers the load to the gravel layer. The design was based on a specified loading of 25 tons per pile. The heaviest column required 15 piles. The entire foundation comprises 81 column footings with a total of 905 piles, an average of about 11 piles per footing.

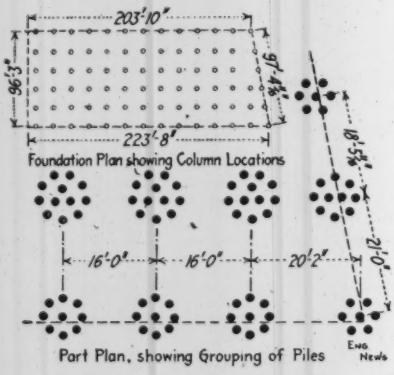


FIG. 1. PLAN OF CONCRETE PILE FOUNDATION OF ALLING & CORY WAREHOUSE, PITTSBURG, PENN.

The circular grouping which is seen in the detail sketch in Fig. 1 was adopted with a view to economy in the footing-slab construction and uniformity of load distribution over the piles. By placing an inner circle of piles directly under the column and an outer circle under the edge of the slab, the designer believed that the symmetry of load on the slab would insure giving equal loads to all the piles, and thereby secure the best utilization of the piles and of the slab.

Some interesting points may be noted in the execution of the pile contract. The work was carried out during the months of October to December, 1911. The piles were molded on the ground, and were driven with unusually heavy rams. The piles have longitudinal and spiral reinforcement, and special cap and point protection, under patents of Mr. Cummings. In the colder part of the period, the piles were steamed to set the concrete more rapidly. Only about 1% of the piles broke in driving.

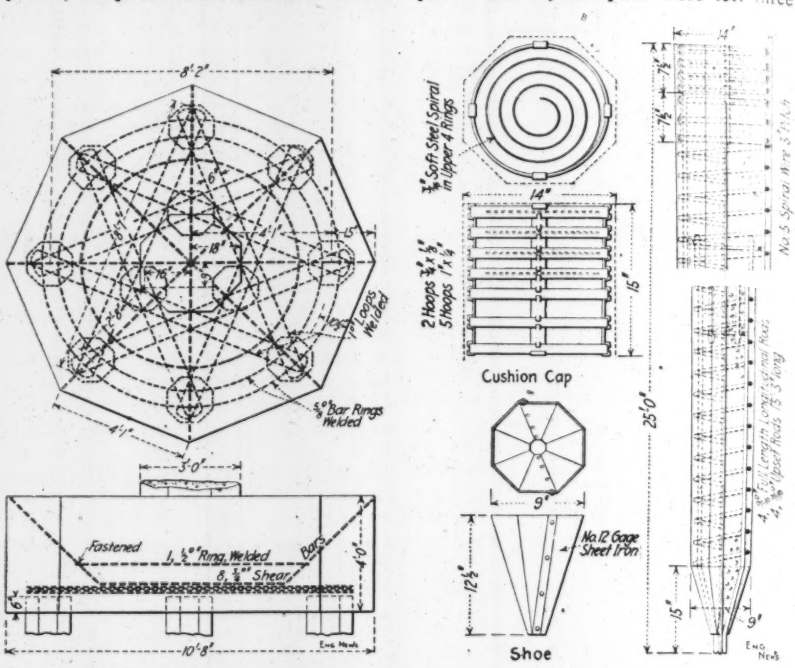


FIG. 2. PILE AND FOOTING DETAILS; FOUNDATION OF ALLING & CORY WAREHOUSE

REINFORCEMENT—The pile reinforcement is shown in the sketch, Fig. 2. The longitudinal reinforcing bars are welded together at the point and welded to a conical sheet-metal point protector. At the head there is a series of horizontal bands of close spacing to give special lateral support to the concrete under the driving shock and the upper four of these contain each a horizontal spiral, as shown by a plan sketch. This form of reinforcing for the pile head has proved to be very resistant to the destructive effect of the pile-driver ram.

The piles were molded on a horizontal platform, using only two side molds consisting of boards with triangular battens attached at top and bottom to give the octagonal shape, the upper face being left open. After 24 hours the side forms were removed and used in molding other piles. Usually the piles were left three weeks before driving; in a few cases piles only ten days old were taken by the pile-driving crews, but many of these broke and thus showed that they were too green for driving. It may be remarked here that on the entire job about ten piles were broken in driving, and in each case it was found that a green pile had been taken in spite of the plain paint marking of date on the side of the pile.

PILE-HEATING RIG—During the December cold weather, it was thought best in order to hurry the setting up of the concrete to arrange for treating them with steam. This was done by building stacks of piles and constructing a wood and sheet-iron housing around them, Fig. 3, with a steam pipe feeding in steam. The stack was made by laying a row of piles side by side on a platform on the

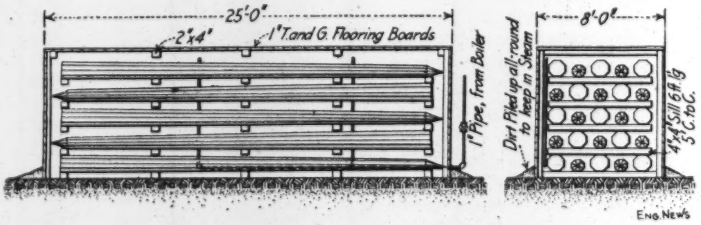


FIG. 3. SECTIONAL SKETCH OF PILE-STEAMING ARRANGEMENT

(Piles remained in this shed two days and three nights when temperature was freezing or below. In all cases they were driven within ten days, without sign of failure, standing as well as piles 30 to 40 days old set normally in weather above freezing.)

ground, then several spacer strips across these, another row of piles on the spacers, and so on for a depth of half a dozen layers. The arrangement worked successfully, and hastened the setting of the piles very materially, so that usually 24 or 48 hours' treatment was sufficient to give a pile a hard enough set for driving.

The piles were molded 25 ft. long, with a few individual exceptions. They were 14 in. in diameter at the butt and 9 in. at the point. The reinforcement consisted of eight ⅝-in. longitudnal rods and No. 5 wire spiral of 3-in. pitch. Wet concrete made of 1:2:4 mixture with gravel was employed.

DRIVING—Driving was done by three pile-driving rigs, all equipped with exceptionally heavy rams: one ram of 7000 lb., one of 10,000 lb., and one of 12,000 lb. The heaviest, the 12,000-lb. hammer, was the most efficient. The drivers used an average drop of 8 ft., and piles were driven until the average penetration per blow was $\frac{1}{16}$ in. Some were driven considerably harder, however, in order to set them down lower and avoid cutting off.

The penetration varied on different parts of the lot, and over one area in particular the ground was soft enough to require the piles to be driven about 16 ft. below ground level. Some 20% of all the piles stopped at or above ground level, and these had to be cut off at the specified cutoff elevation, which was fixed at 1 ft. above the bottom of the column-footing slab. In the case of those piles which went far below this level, the column footing was simply constructed at the lower level and the column lengthened.

Pile driving was started on Nov. 8 and finished on Dec. 14, 1912, working during the day only. All three drivers worked during the entire period.

The pile-driving work was done by the Cummings Structural Concrete Co., as subcontractor under James Stewart & Co., general contractor for the building. The Hunting-Davis Co. acted as engineer and architect. All these firms are of Pittsburg, Penn.

A 3300-Ton Testing Machine

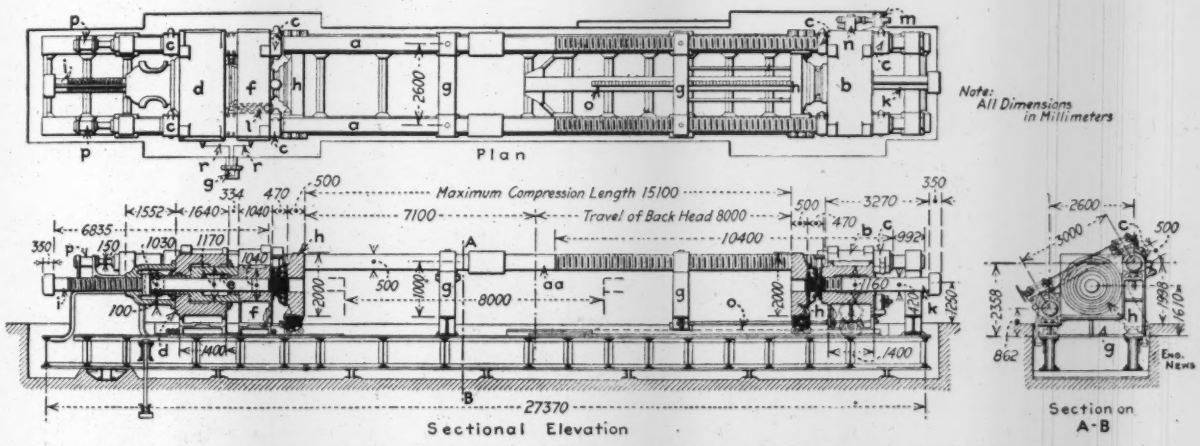
A very large testing machine is now being erected at the Prussian Testing Institution (Königliches Materialprüfungsamt), at Gross-Lichterfelde, Germany. It was built with funds provided by an association of German bridge builders and is intended primarily for the purpose of making tests of full-size structural members. The firm of Haniel & Lueg, of Düsseldorf, built the machine, after designs made by Dr. Seifert, president of the association of bridge builders, in conjunction with officials of the Testing Institution. The machine has a capacity of 6,600,000 lb. in compression, taking members up to 49 ft. long, and a capacity of 3,300,000 lb. in tension, taking members within a length range of 26 ft. to 42½ ft. It is a horizontal hydraulic machine. If we except the 5000-ton machine built two years ago for the Geological Survey and now being erected at the Pittsburg testing station of the Bureau of Standards, the Berlin machine is the largest compression machine in the world. Some of its main dimensions are approximately as follows: The compression cylinder has an outside diameter of 75 in. and a bore of 48 in., and weighs 44 tons; the screw spindles (two) are 19 in. in diameter and 82 ft. long over all, and made in two sections whose combined weight is 44 tons; the back head weighs about 35 tons; the entire machine is 95 ft. long by about 14½ ft. wide, and its longitudinal axis is 50 in. above floor level.

The illustration herewith shows general drawings of the machine, taken from *Stahl und Eisen,* of Mar. 7, 1912, where the machine is described. It will be noted that the spindles *a* are not in the same horizontal plane, but the front spindle is low and thus the working aperture of the machine is made more accessible. The bed of the machine is formed by a frame of heavy plate-girders connected by transverse diaphragms. The spindles are made in two parts each, joined by couplings; they are supported at one end in fixed supports and at other points by supports resting on the frame by wheels. For making compression tests the cylinder *d* and the back head *b* are locked to the spindles, while for tension tests the cylinder is free but the ram *e* is connected to the spindles; in the latter case the bearing plates used for compression testing are removed and tension bars *i* and *k*, which are housed centrally in cylinder and rear head, are slid forward and fitted with grips or other means for attaching the test-piece. The ram has a crosshead *f* for fixing it to the spindles. This crosshead also contains two pullback rams *l* for making the return stroke of the main ram. Two-part nuts *c*, operated by screw gearing, are provided at both ends of the machine for locking the heads to the spindles. The back head can be moved 25 ft. along the spindles by the motor *m*, geared to a pinion which engages a rack *o* set along the center of the bed-frame.

The bearing-plates *h* for compression tests are square, about 6½ ft. on a side. They have spherical seats and the friction of these seats is reduced by an oil film, to make the plates perfectly self-aligning. When the bearing-plates are in position, the tension bars *i* and *k* must be pulled back to the position shown in the drawing.

The principal parts of the machine, such as cylinder, crosshead, yokes, bearing-plates, and back head, are steel castings. The spindles, tension bars and plunger are steel forgings. The plunger is packed with leather cup packing.

To absorb the energy of rupture of test-pieces, hydraulic brakes *p* are fitted to one end of the screw spindles. A maxi-



LONGITUDINAL SECTION, PLAN AND CROSS-SECTION OF THE NEW GERMAN 3300-TON TESTING MACHINE

mum pressure of 200 atmospheres is provided for in the brake cylinders.

The main cylinder is supplied with pressure water by a special pumping plant. The pressure used is 400 atmospheres for compression and 200 atmospheres maximum for tension tests. A low-pressure supply of 50 lb. per sq.in. is available for idle movement of the plunger.

Two pressure gages for indicating the pressure in the main cylinder, and a gage for measuring the pressure in the pull-back cylinder, form the indicating equipment of the machine, together with further gages for the accumulator, etc.

According to a recent article by Prof. A. Martens, Director of the Prussian Testing Institution, a volumetric load gage of 3300 tons capacity has been designed and is being built for trial use in this machine. Should this apparatus prove successful the load indications of the machine in compression tests can always be obtained through the volumetric gage with a high degree of precision, and dependence need not be placed on the gage readings of cylinder pressure.

Extensive Port Improvements at Seattle, Wash., are under way and others have been authorized. General H. M. Chittenden, chairman of the Seattle Port Commission, is reported as having made up the following summary:

PUBLIC FUNDS PLEDGED

Public Agency	Location of Improvement	Amount Pledged
U. S. government	Lake Wash. canal	$2,275,000
State	Lake Wash. canal	250,000
County	Lake Wash. canal	750,000
County	Duwamish waterway	600,000
Assessment district	Duwamish waterway	1,000,000
County	Renton waterway	50,000
Assessment district	Renton waterway	50,000
Assessment district	Sammamish river	50,000
Port district	Smith Cove dock	1,000,000
Port district	East waterway dock	850,000
Port district	Central W. F. dock	750,000
Port district	Harbor island (1)	3,000,000
Port district	Harbor island (2)	2,000,000
City	Harrison St. dock	25,000
County	Duwamish dock	350,000
Port district	Salmon bay	350,000
Port district	Lake Wash. ferry	150,000
Total pledged		$13,500,000

Funds—Public and Private

Terminal Co.	Harbor island	$2,275,000
Port district	Deferred projects on Elliott bay and canal when opened probably	1,750,000
U. S. government	Duwamish waterway, probably	225,000
Local agencies, public and private	Bridges, subways, docks and related improvements, probably	2,250,000
Total		$6,500,000

Summary

Public funds pledged or in process of raising	$13,500,000
Public and private funds in early prospect	6,500,000
Total for harbor in next five years	$20,000,000

At the recent March election $8,100,000 of bonds for port improvements were authorized by popular vote. These, we understand, are included in the foregoing summary.

New Sand Drying Plant of the United Railways Co., St. Louis, Mo.*

By C. L. Hawkins†

The United Railways Co., of St. Louis, Mo., operates 1400 electric cars. The company has a track mileage in the city and county of 474 miles, 114 miles of which is on private right of way. The average track grade is 2½%.

The amount of sand used per month varies from about 300 cu.yd. during the summer months, to 1300 cu.yd. during the winter months, the total for a year being about 6000 cu.yd. All of this sand is dried at one plant and delivered to bins, holding about 35 cu.yd. each, located at car barns and at various places along the tracks. There are 34 such bins, holding in all 1400 cu.yd., or about one winter month's supply.

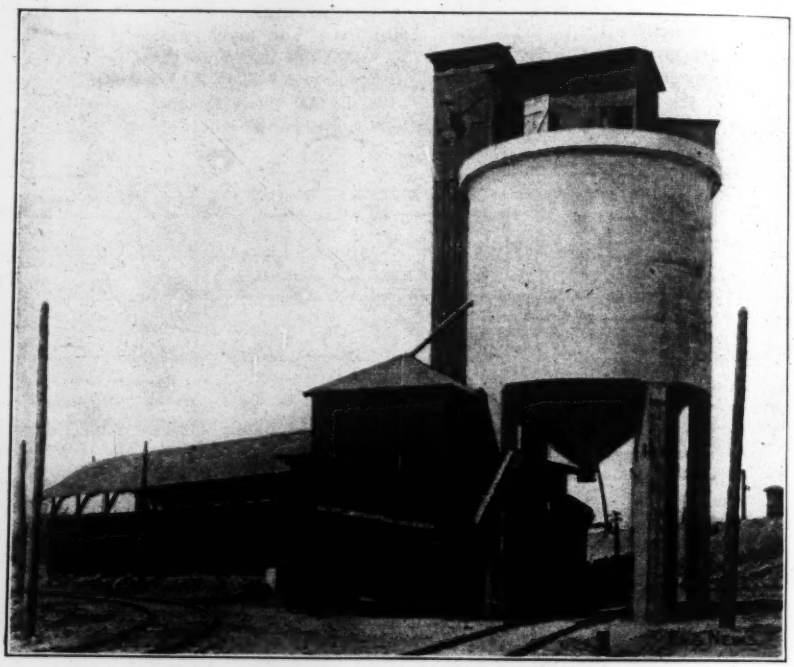


FIG. 1. SAND-DRYING PLANT OF THE UNITED RAILWAYS CO., ST. LOUIS, MO.

The location of the new sand-drying plant is near the Suburban Garden at the western limits of the city. The yard is on the south side of the Inner Belt Line tracks of the Terminal Railway Association. The sand is brought by rail, and is the ordinary bar sand dredged from the Mississippi River by the Union Sand & Material Co.

A cross-section and plan of the plant is shown in Fig. 2. The river sand is dumped directly into the wet-sand pit from side-dumping cars. Two apron belt conveyors carry it from the openings in the botton. of the pit and deliver to a belt conveyor leading to a rotary dryer.

The dryer consists of a revolving steel cylinder 4 ft. in diameter and 20 ft. long, supported above a hand-fired furnace burning slack bituminous coal. The axis of the cylinder is inclined about ½ in. per foot. The sand received at the upper end is tossed about by six curved blades, while an exhaust fan draws hot gases around the cylinder and then into it through openings in the periphery, thus bringing the hot gases into direct contact with the sand as it travels toward the lower end of the cylinder.

The sand contains considerable gravel and upon discharge from the dryer it is conveyed by a bucket elevator to a revolving screen located on top of a cylindrical reinforced-concrete bin. From this screen the sand falls directly into the bin and the gravel passes through a chute leading to an elevated gravel bin.

The wet-sand pit is designed to hold 3000 cu-ft., about two days' supply; half of this will slide into the conveyor without shoveling. The pit is 35x10 ft. in plan and 8 ft. deep. It is built of concrete with a floor 13 in. thick, reinforced with ¾-in. square rods 6 in. apart. The walls are plain concrete 2 ft. thick. The sloping part of the walls was reinforced with ½-in. square bars 12 in. apart. For all reinforced concrete a 1:2:4 mixture was used; for plain concrete a 1:3:5 mixture. The mixing was done by machine.

The four sides of the tunnel leading from beneath the pit are 15 in. thick and reinforced with ¾-in. rods 9 in. apart. The dirt bumper on top of the tunnel (see

*Abstract of a paper in the February "Journal" of the Association of Engineering Societies.

†Engineers' Club of St. Louis, Mo.

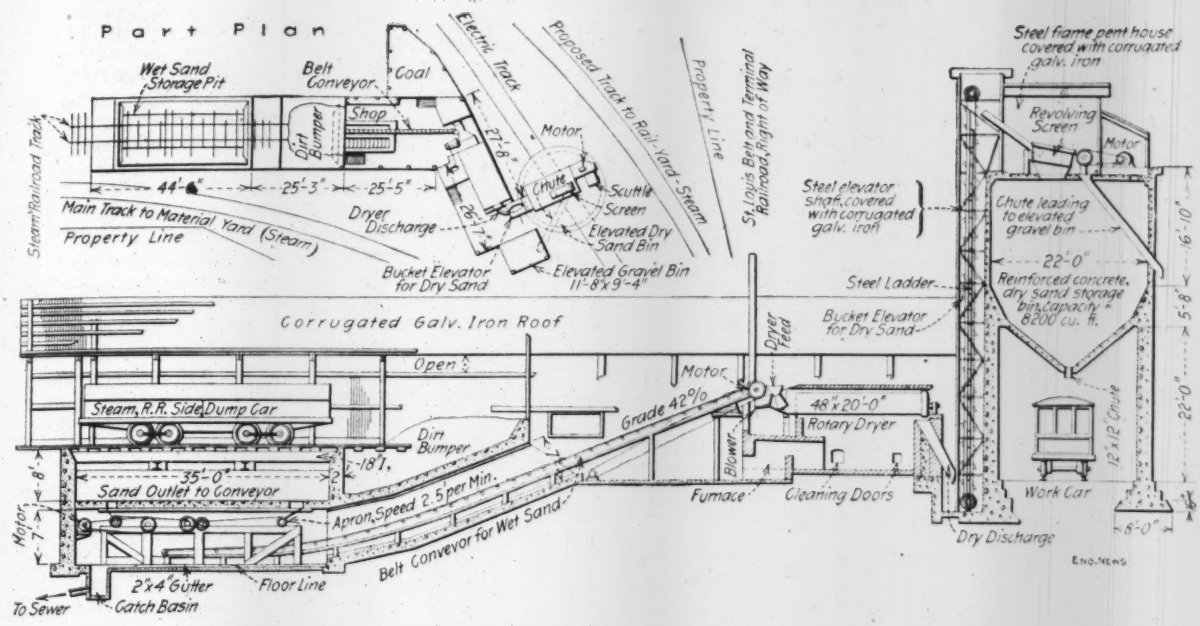


FIG. 2. CROSS-SECTION AND PLAN OF THE SAND-DRYING PLANT OF THE UNITED RAILWAYS CO., ST. LOUIS, MO.

cross-section, Fig. 2) is at the foot of a 2% grade 1200 ft. long, and on account of the damage that might result from careless switching, the tunnel was made considerably stronger than the actual load conditions required. For temperature reinforcement ½-in. square bars were used in the reinforced parts of the pit and tunnel.

In the design of the cylindrical dry-sand bin, which has a capacity of 8200 cu.ft., fluid pressure at 100 lb. per cu.ft. was used in computing the side and bottom reinforcement. The circular beam resting on the posts was designed to hold 0.4 of the sand load and the conical bottom the full load.

The vertical side walls of the bin are 7 in. thick, and the ring reinforcement increases from ⅜-in. square bars 12 in. on centers at the top to ¾-in. square bars 6½ in. on centers at the bottom. Vertical rods, ½-in. square bars, are placed 18 in. apart to take temperature stresses. The conical bottom is 9 in. thick with ring reinforcement varying from ¾-in. square bars 6½ in. apart to ⅝-in. bars 9 in. apart. The radial reinforcement of the bottom consists of 120 bars, ¾ in. square, 30 of which are carried to the opening at the bottom, while the others stop at the ¼, ½ and ¾ points.

The circular beam is reinforced with 11 bars 1 in. square, 7 of which are at the bottom. The roof is 9 in. thick, with reinforcement running both ways. The columns are 24 in. thick with ¼-in. square bar hoops, 12 in. apart, and eight vertical bars ¾ in. square.

The gravel bin is built of wood, as is also the frame of the building surrounding the dryer and the wet-sand pit. The frames of the elevator tower and the screen house on top of the dry-sand bin are 3x3x⅜-in. angles. The outside of all these buildings is covered with corrugated galvanized iron.

The conveying and screening machinery was furnished by the Link Belt Co., and consists of two apron conveyors of ⅜-in. steel overlapping corrugated pans of 9-in. pitch and 18 in. wide, attached to a steel bar link chain; a 14-in. conveying belt made of 4-ply rubber belting with ⅛-in. rubber covering, which carries the sand up a 42% incline very satisfactorily; a bucket elevator consisting of 7x4½x4-in. malleable-iron buckets 12 in. apart on a 4-ply rubber belt; and a screen 36 in. in diameter, 6 ft. long, with ⅜-in. openings. Four motors are used to operate this machinery.

The cost of the buildings and machinery for this plant was approximately $14,000. The plant is operated by two or three men (from one of the car houses), depending on the condition of the sand; these men unload the cars, fire the furnace, watch the moving parts and keep them properly oiled, and keep the plant clean and in good order. On one of the first tests before the machinery speeds were properly adjusted the following results were obtained:

Moisture, 4%.
Length of tests, 18.8 hr.
Cubic feet of sand dried, 2650.
Pounds of coal used, 4340.
Power used, 240 kw.-hr.
Weight of water evaporated per pound of coal, 2.45 lb.
Tons of sand dried per hour, 7.05.
Tons of sand dried per ton of coal, 61.

Cost of operating machinery per cu.ft. of sand	$0.0044
Cost of power per cu.ft. of sand	0.0009
Cost of coal per cu.ft. of sand	0.0016
Sand and freight per cu.ft. of sand	0.0172
Interest, depreciation and taxes (12%)	0.0104
Total	$0.0345

After this test the dryer speed was increased and a new test made. The sand at this time contained 3¼% of moisture.

The length of test, 13.5 hr.
Cubic feet of sand dried, 3200.
Pounds of coal used, 4400.
Power used, 300 kw. hr.
Weight of water evaporated per pound of coal, 2.55 lb.
Tons of sand dried per hour, 11.84.
Tons of sand dried per ton of coal, 73.

Cost of labor per cu.ft. of sand	$0.0026
Cost of coal per cu.ft. of sand	0.0012
Cost of power per cu.ft. of sand	0.0009
Cost of sand and freight per cu.ft. of sand	0.0172
Interest, depreciation and taxes (12%)	0.0104
Total	$0.0323

The total cost of drying 6000 cu.yd. of sand by the stove method, including the cost of maintenance, etc., of the necessary dry-sand storage bin, would amount to about $7290 per year. The total cost of drying at the new plant, figured at $0.0323 per cu.ft., is $5232.60, a saving of $1957.40 per year over the former plant, $510 of which is due to the saving of $3 per car for switching charges, due to a more favorable location.

A Rapid Transit Tunnel six miles long is proposed in San Francisco, between the junction of Market and Valencia Sts., near the City Hall and the Lake Merced district to the southwest, which is separated from the city on the north and east by a high range of hills. The tunnel will run for about a mile under Market St. in order to bring the terminus closer to the business district and to connect up with future transit development. The grade would be uniform at about 1%, bringing the western portal some 300 ft. above the eastern. It is proposed to assess the cost of building this tunnel on the districts most benefited, the assessments being estimated at about 1.55c. per sq.ft., amounting to from $35 to $50 per lot; 10 years would be given for payment.

Valve and Cylinder Lubrication of Locomotives Using Superheated Steam

The extensive and increasing use of superheated steam for locomotives has introduced some special problems and difficulties as to the proper lubrication of moving parts subjected to the influence of such steam. This subject was dealt with in a paper read at the March meeting of the Western Railway Club (Chicago) by P. H. Conradson, Chemist of the Galena Signal Oil Co. We give herewith some of the points brought out both in the paper and in the discussion which followed it. Saturated steam possesses a certain lubricating quality owing to the presence of suspended water particles or moisture. Superheated steam apparently has no such quality, at least for a high degree of superheat which makes the steam absolutely dry. With such high superheat, condensation in the cylinders is prevented, and dry or superheated steam passes out as the exhaust. For engines using superheated steam, therefore, it is necessary to give close attention to the lubrication of valves and cylinders; this involves not only the use of a proper grade of oil, but also the design of the parts and the grade of metal used in their construction. In regard to this question of the metal, one road using a rather high degree of superheat (200 to 250° F.) had its piston and piston-valve rings made of the same ordinary gray iron as used in engines working on saturated steam. These rings wore out so rapidly under the effect of superheated steam that a dense fine-grained air-furnace iron was substituted, with the result that the life of the rings increased from 1000 miles to 18,000 and even 30,000 miles.

There has been some apprehension that valve oil would not stand a high degree of superheat, but would burn or carbonize at the temperature of the steam. A valve oil suitable for such use, however, will work satisfactorily at a superheat as high as 800 to 1000° F. On the other hand, if steam is excluded from and air admitted to the cylinder, the best grade of oil will be burned. For this reason it is essential to maintain a slight supply of steam to the cylinders when the throttle is closed and the engine is drifting. This is done to the best advantage by the use of a drifting valve. If such a device is not used, dust and cinders are drawn in and cause deposits to accumulate in the cylinders and steam chests; a small amount of oil serves to bind a large amount of this matter, forming a sticky deposit on the metal which bakes very hard under the action of superheated steam. When such a deposit is found, it is very generally assumed that it comes from carbonized oil, whereas it is composed mainly of ashes, cinders and mineral matter.

The use of superheaters on engines supplied with alkali or foamy water helps to improve the lubrication, as the highly saturated steam (due to spray or priming) is converted into dry steam, instead of passing to the cylinders and washing away some of the oil. Thus the lubrication is better, although less oil may be used. While some roads claim to get satisfactory results with flat slide valves on engines using superheated steam, the degree of superheat in such cases is usually low. With a high degree of superheat, piston valves are considered essential for successful lubrication.

In the earlier stages of the use of superheaters, it was considered necessary to supply the oil at different points, and valve oil was usually fed both to the cylinders and the steam chests; sometimes at five or six points. As experience has increased, however, the number of feeds has been reduced. With simple engines, some roads now employ only a feed to each steam chest, or into the steam pipe (or saddle casting), eliminating the feed from the cab lubricator to the cylinders. With compound engines, there may be a single feed to the high-pressure steam chest (or steam pipe), but when drifting it is advisable to feed some oil to the low-pressure steam chest through the steam pipe of the drifting valve. In earlier practice, also, it was usual to provide mechanical pumps for the oil feed, in addition to the hydrostatic lubricator, in order to guard against possible failure of the feed. But the pumps have been generally eliminated, the lubricator being found sufficient and reliable.

An important factor in successful lubrication is the condition in which the oil is introduced, especially in view of the small amount of oil and the large surfaces it has to cover or lubricate. Experiments with atomizing the oil, spraying it in the form of a fine mist mingled with steam, gave such satisfactory results that the method has been worked out on a practical basis and is used in a number of cases. In fact, the system is said to be applicable with equal advantage to locomotive and stationary engines working saturated steam.

Owing to the varying conditions of the steam, which will be practically saturated when starting up after a stop at a station or siding, the grade of oil used for lubrication with superheated steam must be suitable for a wide range of conditions. The following requirements were stated by Mr. Conradson: 1, it should be readily emulsified and atomized with the steam; 2, it should have the requisite body or viscosity, with sufficient adhesive property to properly lubricate at the highest temperature found in service without carbonizing, and be free from gummy, tarry and asphaltic constituents; 3, it should fulfill its functions, whether the engine is working under saturated or wet steam conditions, or with the highest degree of superheated steam, or during drifting. In other words, the oil should adapt itself readily to the above variable conditions; it must be not too volatile, not too sluggish, readily intermingling in a highly divided state with the steam, and spreading itself in this condition over the surfaces to be lubricated.

In the discussion of the paper, Mr. Symons, consulting engineer, pointed out that not all roads have solved the problem of successful lubrication on locomotives using steam of high temperature. In some cases, such engines have been difficult to lubricate and rather expensive on certain items of repairs. On the other hand, some troubles encountered and charged to the lubricator or the oil have been readily overcome, and it has been found that even the lubrication of Mallet compound engines using highly superheated steam is not a difficult matter. He quoted the following statement from the report presented by the Committee on Cylinder Lubrication at the 1911 meeting of the American Railway Master Mechanics Association:

> There is no difficulty whatever in obtaining satisfactory lubrication in superheater engines with hydrostatic lubricators on account of difference in pressure between steam chest and boiler. In fact, there is considerably less difficulty than on engines using saturated steam. In spite of this, however, the piston-ring wear is far more rapid.
>
> The problem of satisfactorily lubricating with Mallet compound locomotives is still in process of solution. At present it seems essential to pipe independently into the high- and low-pressure cylinders. However, there has been some experience with satisfactory results by eliminating the pipes to the low-pressure valves and cylinders, substituting an auxiliary pipe to the receiver with the high-pressure steam connection. This carries sufficient oil over to the low-pressure cylinders to insure good service.

As to the atomizing of the oil, it was suggested by Mr. Squire that with this process the entire body of steam carries lubricant in suspension, while only that portion of the steam which comes in direct contact with the metallic surfaces of the cylinder will deposit this lubricant (under the influence of the relative cooling effect of such contact). If this is the case, perhaps 99% of all the oil fed to the cylinders might do no useful work but would be carried out with the exhaust. Mr. Conradson admitted that a large proportion of the oil is carried off in this way; nevertheless, the proportion of oil in the steam is much lower at the exhaust than at the admission, the oil being deposited as the temperature of the steam reduces. But by atomizing the oil and delivering it in this form into the steam chest or the saddle the oil is distributed more effectively, as indicated by the reduced wear on piston rings, bushings, etc., where atomizing devices are used.

Trouble with the lubrication of valves on superheater engines was noted by Mr. Young (Pennsylvania R.R.), this being the case on heavy passenger engines running between New York and Harrisburg. This he considered due to inexperience of the men, who were apt to close the throttle entirely when checked by a green signal. This trouble practically disappeared after the men had been instructed and shown that there must be some steam passing through the cylinders all the time. While he approved of atomizing the oil, he thought the same effect could be obtained by feeding the oil into the steam passages far enough back to permit it to mingle with the steam before reaching the valve. Mr. Conradson did not agree with this. Mr. Young remarked also that in Germany forced-feed lubricators are used on superheater locomotives, while the general practice in this country is to use hydrostatic lubricators. In experiments at the Pennsylvania R.R. locomotive-testing plant, with 650° superheat, it has been found that the temperature of the wall of the steam chest is as much as 100 to 200° higher than that of the wall of the cylinder.

In Channeling Rock, the operators of stone-channeling machines occasionally encounter difficulty in putting down cuts, owing to side pressure or creeping of the rock, which is under initial compression. According to a note in "Mine & Quarry" (Sullivan Machinery Co., Chicago), this usually occurs in limestones or sandstones which have been heaved up, or through some other disturbance have settled and placed the layers under a lateral strain. An interesting example of this occurs in the sandstone beds in northern Ohio, at Amherst and vicinity. The usual method of opening a quarry in this field is by cutting two parallel channels about 6 ft. apart and removing the key blocks across the end of the quarry. This affords room for the expansion which takes place, and which amounts sometimes to 4 or 5 in.

Difficulty from side pressure was encountered by the contractors for the new canal and lock at Sault Ste. Marie, Mich., where the Potsdam sandstone is very hard and in layers of irregular thickness and pitch. On the New York barge canal the Niagara limestone, near the west end of the undertaking, has also given trouble from this source. After a cut has reached a depth of 6 ft., pressure begins to act and closes up the cut entirely. The same condition was encountered in excavating the long wheel pit for the first Niagara power station.

Evidence of the pressure is found in the fact that the rock is badly broken and splintered. To avoid trouble from this source the contractors have adopted the plan of blasting out a center cut through the length of their section, some 25 to 30 ft. in width, before starting to channel. As the canal is 94 ft. in width, this leaves a 32-ft. bench on each side, and the danger of shattering the permanent side walls, to avoid which channelers are employed, is very small. This center cut relieves the side pressure, so that when the channel cuts are put in, the channel made by the machine does not close up.

Chief Requisites for Success in the Engineering Profession*

By Chas. T. Main†

The road to success in any business or profession is not an easy one. This is particularly true with reference to the profession of engineering. It appears to me that the chief requisites for success are about as follows:

Some natural bent or liking for the work and a good stock of imagination. This may be inherited or acquired.

Close application in the work of preparation in the school, office or field, without many outside attractions.

Industry for many years after the first years of preparation. It sometimes seems that the application is too close, but it is difficult to make a success without close application and it is a rare person who can give much time to play and yet succeed in business. Occasional let up or change of work is necessary, but for the greatest success it seems that we must work most of the time during the working years and later give up practically all of the detail to the younger men, reserving only the direction of policies, consultation work and general guidance of the business.

Knowledge of the fundamental principles of engineering which underlie all practice. This should be the aim of the scientific schools rather than an attempt to cover too much detail. The latter can be acquired after the school years. The great majority of graduates of the scientific schools take up some line of work which is different from what they had expected. It is for this reason that a man should be well grounded in fundamental principles, so that he may undertake with some intelligence any work which is put up to him.

Integrity in work and business and fairness and justice to all. In the long run, a reputation for integrity in all his dealings, rather than brilliancy in attainments, will do more than anything else for promoting the business of a capable engineer.

Some business knowledge. This is the thing which is usually lacking in the young graduate. More time spent on business law, preparation of specifications and contracts and some in common letter writing would be of great benefit.

The engineering courses in technical schools are, as a rule, not broad enough in this respect. They do not tend to make a young man a broad thinker nor a good mixer. If a man can afford the time and money, a combination of the college and technical school should be of great advantage to him.

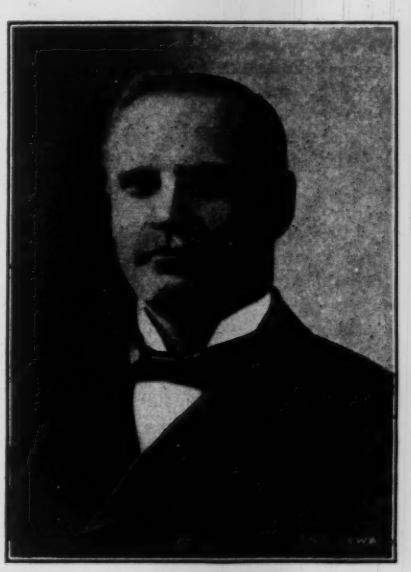
And, last of all, but perhaps the most important, is good judgment, called, oftentimes, "horse-sense," in the application of fundamental principles of engineering and everyday life.

*Extract from Presidential Address before the Boston Society of Civil Engineers, Mar. 20, 1912, to appear in the "Journal of the Association of Engineering Societies."

†Consulting Engineer, 210 Devonshire St., Boston, Mass.

A Testimonial to Dr. James E. Denton from the Alumni of Stevens Institute

The recent retirement of Dr. James E. Denton from the Chair of Engineering Practice at the Stevens Institute of Technology has been made the occasion of presenting him a testimonial bearing witness to the esteem and affection felt for him by the Institute's alumni.



Dr. James E. Denton

Dr. Denton is himself an alumnus of the Institute, and since his graduation in 1875 has been continuously a member of its faculty. In 1906 his alma mater conferred upon him the honorary degree of Doctor of Engineering; he was the first alumnus of the Institute to be thus honored.

Aside from his work as Professor of Mechanical Engineering, Dr. Denton has long had high reputation as a consulting engineer, his principal work being in steam engineering. He has been a member of the American Society of Mechanical Engineers since 1881, and was a manager of the society from 1889 to 1892.

The tokens with which the alumni have presented Dr. Denton are a watch and especially designed fob and an engraved testimonial bearing the signatures of many alumni and professors of the Institute.

Letters to the Editor

Five-Year Tests on Cement Briquettes

Sir—The five-year tests of cement briquettes as published in the article by C. A. Morse in ENGINEERING NEWS, Mar. 14, 1912, p. 470, are of such interest that I am sure many of your readers regret that more data were not given.

Permit me to ask for (1) the charts of each briquette; (2) What water, sand and brand of cement was used in each? (3) How were the briquettes mixed? (4) How were they compacted? (5) If immersed in water, for what time and at what temperature? (6) If seasoned in air, what was the humidity and temperature?

ERNEST L. RANSOME.
90 West St., New York City,
Mar. 18, 1912.

[The above letter was submitted to Mr. Morse and we have received from him the following reply.—ED. ENG. NEWS.]

Sir—As I am in receipt of quite a number of inquiries similar to those of Mr. Ransome, I am handing you herewith copies of the reports from which the diagrams were made up which were furnished you for publication. You will note that each of these reports shows five briquettes, both of neat cement and 1:3 mortar, and the average of the five. [Not published here on account of lack of space.—ED. ENG. NEWS.]

Regarding Mr. Ransome's list of questions:

The water used in the laboratory for these tests was from the mains of the Iola Portland Cement Co., and is pumped by them direct from Elm Creek, a stream near their works. The sand was standard crush quartz from the Garden City Sand Co., and tests were made to be sure that it was standard. The cement was Iola, made by the Iola Portland Cement Co., of Iola, Kan., and "Sunflower," made by the United Kansas Portland Cement Co.

The briquettes were mixed by hand on a marble slab. Three parts of sand and one part cement by weight, and with 10% water. The sand and cement were carefully and thoroughly mixed dry, after which the water was added, enough mortar to make ten briquettes was mixed at one time.

The manner of molding was as follows: Mold is placed on an iron base, filled with mortar and tamped with an iron spatula, turned over, refilled and again tamped. Briquette is removed at once and placed in damp box. The briquettes are arranged on sheet-iron trays on heavy building paper that has been soaked in water.

Briquettes are kept in the damp box for 24 hours; they are then kept in a water bath until broken. The water baths, or briquette tanks, are about 4 ft. long, 2 ft. wide and 7 in. deep. The briquettes are stacked five high. The temperature of the laboratory is 70° to 75° F., and is kept very uniform. The only change in the temperature of the water in the tanks is when the water is changed about once a month.

The damp box in which the briquettes are kept 24 hours is about 2 ft. square and 7 ft. high and is divided into four racks, each rack is covered with two thicknesses of heavy soft building paper. This paper is kept wet. The temperature of the damp box is 72° F., the humidity 82°. The green briquettes are placed on sheet-iron trays, and are then placed in the damp box.

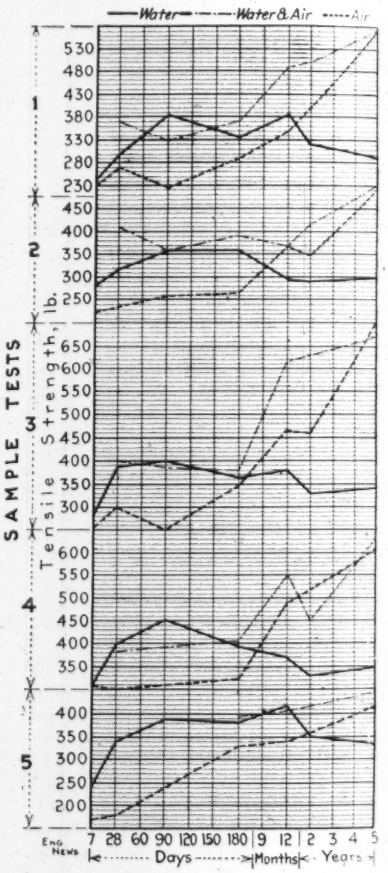
As stated in the original article, these briquettes were all made, cared for and broken by one man in the same laboratory, and under the same conditions, during the whole five years, so that the question of personal equation is entirely eliminated, and the question of possible variation in tamping is practically eliminated, inasmuch as the same party that made these tests has been testing cements for 11 years for this company, and naturally the amount of tamping given the briquettes under these conditions is practically uniform, something that it would be impossible to do where different parties make the different sets of briquettes.

It would be interesting to see diagrams of portland cement tests showing an increase in strength up to seven to nine years, rumors of which have come to the writer. The writer has been making cement tests off and on for the last 17 years, and at least 15 years ago began to notice in German portland cements, and in cements manufactured in Ohio and Michigan, that in the case of one to three briquettes, the high point was reached in from 90 to 120 days. At that time our tests were carried only for a period of from six months to a year, and it was due to noticing this general result among the different cements tested that the five-year test, the results of which were published, was carried on.

C. A. MORSE.
Atch., Topeka & S. Fe Ry.,
Topeka, Kan., Apr. 17, 1912.

Another Series of Five Year Tensile Strength Tests of Portland Cement Mortar

Sir—The publication by C. A. Morse, in ENGINEERING NEWS, Mar. 14, 1912, p. 470, of a series of tensile strength results for five-year tests of portland-cement mortar has called attention to a most interesting feature of portland-cement testing. The results of another series of five-year tensile strength tests of portland-cement mortar made of one part portland cement with three parts of standard crushed quartz sand are given herewith in the form of two tables, one showing the varying strengths expressed by curves and the other in figures of pounds per square inch. The latter table is given



FIVE-YEAR TENSILE TESTS ON 1:3 PORTLAND CEMENT MORTAR

(Test pieces the same as those in the accompanying table.)

TABLE SHOWING FIVE-YEAR TENSILE TESTS ON PORTLAND CEMENT BRIQUETTES STORED UNDER DIFFERENT CONDITIONS (Strength in Lb. per Sq.In.)

	Stored	7 days	28 days	90 days	180 d's	12 mo.	2 yr.	5 yr.
SAMPLE 1 Tested Apr. 3, 1906 Per cent. through 100 sieve, 92.8 Set initial, ¾ hr. Set final, 6 hr. Water, 9%	In water	248	296	385	334	381	325	295
	In water and air	...	369	329	366	483	491	567
	In air	232	266	225	263	346	402	563
SAMPLE 2 Tested Apr. 5, 1906 Per cent. through 100 sieve, 89.2 Set initial, 2 hr. Set final, 6 hr. Water, 9.2%	In water	282	314	360	360	296	291	292
	In water and air	...	409	362	392	369	419	492
	In air	224	231	259	264	369	347	486
SAMPLE 3 Tested Apr. 7, 1906 Per cent. through 100 sieve, 94.8 Set initial, 2 hr. Set final, 6¼ hr. Water, 9.3%	In water	287	380	400	362	378	331	345
	In water and air	...	398	389	378	611	624	670
	In air	259	301	250	344	462	461	698
SAMPLE 4 Tested Feb. 8, 1906 Per cent. through 100 sieve, 91.3 Set initial, 2 hr. Set final, 6 hr. Water, 9.4%	In water	308	397	451	395	370	328	317
	In water and air	...	382	no test	404	546	457	626
	In air	307	303	no test	323	486	no test	607
SAMPLE 5 Tested July 19, 1905 Per cent. through 100 sieve, 92.2 Set initial, 2¼ hr. Set final, 4½ hr. Water, 9.3%	In water	247	339	387	385	419	352	336
	In water and air	...	no test	no test	394	409	no test	449
	In air	169	179	no test	332	340	no test	414

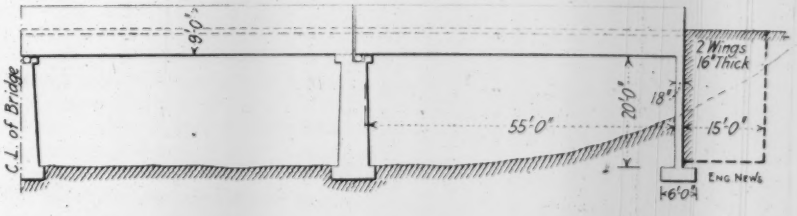
in order to show clearly some periods at which no briquettes were broken.

These tests have the same special value as those published by Mr. Morse, in that they were conducted throughout by one man, and an additional value in that each of the five samples tested was manufactured by a different mill. It will be noted that the series of results given herewith confirms those previously published. Compared with the results given by Mr. Morse, this later series shows a slightly higher average strength at the starting point as well as at the end of five years, but the general tendency of the curves is to run parallel with those given by Mr. Morse. These results, however, cannot be considered as showing the strength action of portland-cement mortar or concrete in general, but merely the action of portland-cement mortar under the methods and conditions customarily used in making tests of same. To demonstrate this, each set of results of tests made in the regular way is accompanied by two sets of results obtained from briquettes made according to the standard methods, but subjected to a different method of storage; the one set after 24 hours in moist air being placed in water for six days and then kept until broken in moist air, while the other set was kept in moist air for the entire period until broken. This remarkably high tensile strength for 1:3 sand mortar obtained after five years by this method of storage, indicates what is most likely the strength action of portland-cement mortar or concrete under the usual conditions of use and accords with the popular idea that such mortar or concrete tends to increase in strength indefinitely or at least to become exceedingly hard and strong after considerable periods of time have elapsed.

S. WARREN HARTWELL,
Chemist, Vulcanite Portland Cement Co.
Easton, Penn., Mar. 28, 1912.

Weak Abutment of a Girder Bridge

Sir—I would like the opinion of your readers on the accompanying design for a reinforced-concrete bridge which is now under contract for erection. The bridge is to be built in accordance with the half elevation shown and is to consist of four deck-girder spans, each 55 ft. clear. The two middle spans are properly supported on suitable piers, and are fixed at one end, with expansion rollers under the other end. But the end spans are supported on abutment walls or legs, so that the abutment end is of the bedstead type. The pier end has an expansion roller.



The supporting leg or wall at the abutment end is approximately 20 ft. high, 18 in. thick, and is supported on an expanded base. The load to be carried by this abutment wall approximates 300,000 lb. In addition it must support the pressure of earth fill behind it. The wall is strengthened against buckling by two wings parallel to the roadway extending back 15 ft., each 16 in. thick, and with no expanded base, but thoroughly reinforced and bonded to the abutment wall.

The doubtful feature of this design, to my mind, consists in the provision for expansion and contraction in the end spans. The earth pressure behind the abutment wall should force the end span tight against the next span, since the U-abutment is not stable against the earth pressure. Subsequent expansion then instead of operating the roller will force the top of the wall back; with the next recurring contraction, the wall will again be crowded forward, due to earth pressure combined with frost and traffic. Instead, therefore, of an operative expansion joint we have the arrangement that is so objectionable in a bedstead bridge, in which expansion and contraction are provided for solely by the backward and forward play of the supporting legs.

It is probable that in this design, if not modified, the weakness of the abutments will ultimately result in the closing of all the expansion joints, thus leaving the structure in a condition of indeterminate stress.

Concrete and steel are known to have substantially the same coefficients of expansion, but I have never known steel-bridge designers to omit such obvious requirements in providing for expansion and contraction. Is it then good design in reinforced concrete?

DANIEL B. LUTEN.
Indianapolis, Ind., Apr. 8, 1912.

Forests and Floods in the Eastern United States

Sir—In your issue of Apr. 11, Gen. H. M. Chittenden has again presented some interesting facts, observed in the Northwest, the region where he now resides—a region of heavy rainfall (two to three times the average in Eastern states) and of atmospheric conditions strikingly different from those over the greater part of the United States. From these he has drawn some startling and sweeping conclusions which he urges against the so called theories and practice of others whose viewpoint is different.

After referring to the topography of a territory "clothed with the densest forests on earth, and with the heaviest covering of decayed vegetation," General Chittenden says:

> The conditions cited by the orthodox forester in support of his theory of the restraining influence of the forests upon floods here exist in perfection, and it is here if anywhere that we should look for practical proof of such restraint. * * * Unfortunately for the theory the facts are the reverse of what it would lead us to expect. For suddenness and violence of freshets these forest streams exceed anything it has been my fortune to observe elsewhere.

Now the subscriber submits that these facts do not justify the distinguished

observer in rapping the "orthodox forester" as a theorist. He is surrounded by conditions which are in some respects extreme—far heavier snowfall; therefore more storage; therefore more water to be let loose when the thaw comes; and such thaw intensified by the "Chinook" winds peculiar to that part of the United States.

But the Eastern man faces other facts, equally valid, which directly contradict the *conclusions* (not the facts) so positively stated by your correspondent. We have our facts at first hand, by personal observation, and from farmers who cut their wood in winter and boil sap in the sugar orchards in March and April, and from the lumbermen who work all winter in our north woods. The writer, as engineer of a local water company, has closely watched conditions in a district of over two square miles tributary to the reservoir, 600 to 1300 ft. above sea level, during a period of 19 years. The General says: "The open mountain country distributes the snow and water over a much longer period, avoids the sharp-crested floods and prolongs the supply far into the summer." Undoubtedly, when there is very abundant snow in the open country. But does the propounder of this sweeping conclusion know by personal inspection that there is *no snow left* in the woods after that in the open is all melted? In northern New England and on the eastern slopes of the Alleghany Mountains the *facts* as we know them are:

(1) The snow and ice invariably disappear from the open country days and sometimes weeks before they are gone from the woods. Although, as everybody knows, northern New England is hilly, with deep valleys, some of them affording quick run-off and also good pockets for storing snowfall, with difference of elevation from 400 to 4000 ft. above sea level, and although there are plenty of ravines and narrow brook beds, the statement last quoted is certainly not true for this section.

(2) Noting that the author of the paper has made no allusion to the effects of sun and wind in *evaporating snow and ice* in the open spaces, attention is called to another fact of common observation: that when there is considerable interval between snow storms the snow from one storm will largely disappear by evaporation, even in quite cold weather; this is also true of ice on the sidewalks and in the streets. The forest cover is altogether a benefit and a blessing, because it shields the deposited snow from direct action of the sun, it breaks the forces of the winds and protects much of the ground from their action and accomplishes the beneficient storage of quantities of water which gradually descend into our ponds and tend to keep our "springs" flowing and reservoirs full during the entire spring and even well into the early summer, in spite of frequent hot spells in May and June. The spongy hillsides hold back the melting snows and thus effectively distribute what has fallen long previously.

Undoubtedly, *if* the woods hold a heavy snowfall and *if* that becomes saturated with rain, and *if* warm winds and warm rains conspire to suddenly let this loose, aggravated floods will follow; but we submit that in the usual operations of nature in most parts of the country such occurrences are only occasional; just as we may have some situations where deposits of gravel and coarse sand so prevail that rainfall disappears almost entirely by soaking in and down, and much of it is lost to the near vicinity.

If General Chittenden will visit the region about the White and Franconia Mountains in New Hampshire and see for himself the mischief that has been done by the clean cutting of whole mountain slopes which are thus exposed to denudation and absolute barrenness after the fires sweep through the slash and the soil is washed away by heavy showers, he would be convinced of the necessity of the forest cover to safeguard the headwaters of our principal streams. The writer has talked with a lumberman who is just back from the winter campaign in northern New Hampshire where 1700 men have been cutting over 50,000 acres, *ostensibly* leaving trees under 6 in. diameter but practically cutting clean. Would the General claim that that region is now in better condition to regulate and distribute the run-off than it was before? If so, we should be obliged to consider that he is the theorist; for *we* are facing a "condition, not a theory."

There are not only two sides to this subject, but many sides; great diversity of conditions, various aspects and many points of view. It is scarcely possible to lay down general conclusions, applicable under all conditions. For any specified region one must needs study all local circumstances before forming opinions or prescribing a course of action. As to the wisdom of endeavors to reforest the slopes of Pike's Peak those familiar with the region are best able to judge; but at the Paris Exposition of 1889 the forestry exhibit showed the wonderful success of the French in promoting forest growth on the denuded slopes of the Pyrenees.

ROBERT FLETCHER,
Director Thayer School of Civil Engineering; Engineer Hanover Water Works Co.
Hanover, N. H., Apr. 15, 1912.

A Specification Fully Met

[It is a cast-iron rule of ENGINEERING NEWS, as of most publications, not to print anonymous communications. Engineers, however, are well aware that cast iron is a comparatively brittle material. It seems worth while to bring this quality into play in order to give space to the following.—ED.]

Sir—Is the gentleman who recently published the following want ad. in your columns one of those who has been so ably discussing the compensation of engineers?

PRIVATE ENGINEER wants assistant. Requirements: Graduate civil engineer (preferred), single man with good habits; must be experienced in mine surveying, farm surveys, and development of coal lands; must be neat draftsman and good letterer, able to do some designing and construction work; duties will be office work, mine surveying, land surveying, superintending construction and municipal engineering; man must be a hustler and work for employer's interest; will pay $75 per month and expenses away from Indiana. Do not make application for this job unless you can fill the bill in every particular. Send sample map work and lettering with application.

Oh, I'm a graduate C. E.,
My habits are the best;
I never have been married,
And I'm always neatly dressed.

I'll drive a tunnel true to line,
Compute the labor cost,
And make a dam so blooming tight,
There'll not a drop be lost.

And I can take topography,
Cross-section cut and fill,
And if you want a bridge designed,
Why I can fill the bill.

My middle name is "Hustle" fast,
Your interests are my own;
I'm a shark at mine surveying,
And I'll starve without a groan.

At city work I'm expert,
And never want my pay;
Seventy-five per looks big to me,
I'll make it less by the day!

Notes and Queries

Referring to the details of the special circumferential joints in the 63-in. steel outlet sewer, at Cleveland, Ohio, illustrated on p. 589 of our issue of Mar. 28, in the article by J. M. Estep, we have received the following note from Geo. H. Fenkell, civil engineer of the waterworks of Detroit, Mich.:

It may be of interest to you and Mr. Estep to know that not only the design itself, but also the details are almost identical with those designed by the writer in 1903, while Civil Engineer to the Commissioners of Water Works, in Erie, Penn. These joints were used on the 60-in. steel intake pipe, which had a total length, when completed, of 10,000 ft. As soon as a few joints had been used it was found by experience that modifications in the joint were desirable, and the design as finally used was the same as appears in the "American Civil Engineer's Pocketbook," at the bottom of page 915.

I have written to the Erie Water Commissioners, asking them to send you a copy of their report of 1904, which contains a drawing of the joints and bulkhead as used at Cleveland, also to send you a blueprint of the joint as finally improved, and used.

The blueprint and report which Mr. Fenkell mentions corroborate his statements. The only material difference between the modified joint used at Erie, and the original Erie and the Cleveland joints, seems to be that the end of the sleeve which comes over the lead pipe is bent outward and the lead pipe flattened in the later Erie joint. Nothing was said in Mr. Estep's article as to the origin of the joint used at Cleveland, which is merely spoken of as "a special submarine joint."

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Engineering News

Running the Highway Department of a Large City without Engineers

Among various other strange revelations which have recently been made at Philadelphia the following is one of the most surprising: When the reform administration came into office recently it found *not a single engineer* in the Bureau of Highways of that great city, from the Chief of the Bureau down to paving inspectors.

The local explanation of this anomaly is that the favored local contractors for street paving, who have ruled Philadelphia so long, preferred to be their own engineers! Of course, the reform administration has changed this. An outside engineer, recommended as well fitted for the position, has been put at the head of the Bureau, and subordinate positions are being filled, we understand, under civil-service rules.

It seems pertinent to inquire why the engineers of Philadelphia did not make vigorous protest against the exclusion of engineers from the Philadelphia Bureau of Highways. A number of the best engineers of Philadelphia have been at the head of its Bureau of Water. The Bureau of Surveys has long and honorably been headed by a well known engineer. Would not the legal profession of Philadelphia have risen as one man to protest against the exclusion of all lawyers from the legal department of the city? Yet it would be no more absurd to try to get efficient legal work without lawyers than efficient engineering work, like street paving, without engineers. But so far as we ever heard, the engineers of Philadelphia never raised voice or pen in protest against the highway department of the city being run without engineers. Was this failure to protest due to a feeling of the hopelessness of the local political situation or merely to apathy?

The Senate Investigation of the "Titanic" Disaster

We do not wish to show disrespect to the high office of Senator of the United States, but it must be regretfully said that the Senate investigation of the "Titanic" disaster reflects no credit on this country, to say the very least. While the zealous promptness of the Senators to make official inquiry into the causes of a disaster which has shocked the civilized world is highly commendable, engineers, at least, must greatly regret that their zeal is not tempered with a larger amount of wisdom.

The reason why Congress is justified in investigating the disaster is, of course, that it may be informed as to what legislation is needed to guard against the dangers revealed by this calamity. The Senate is not a coroner's jury to fix responsibility for the accident, even though some of the questions asked may remind one strongly of coroner's jury procedure. Neither is it the business of the Senate to investigate all sorts of trivial incidents in connection with the disaster simply to gratify idle curiosity and furnish sensational material to yellow journals. There has been far too much sensationalism and personal calumny in the public press already in reference to the disaster. The distinguished Senators of the United States ought to have more important duties than contributing to this end.

The all-important question which their inquiries ought to shed light upon is, what practical lessons does the "Titanic" disaster teach with reference to the design, construction and operation of vessels and the safe conduct of navigation? But in order that the facts which are to teach these lessons shall be clearly established, some modicum of technical knowledge is requisite on the part of the investigators. There is danger that the whole investigation will be brought into contempt when the distinguished Senator conducting it asks such foolish questions as why the passengers did not take refuge in the watertight compartments of the vessel! If this slip were the only one, it might be overlooked; but such questions as whether foggy weather makes any difference in seeing an iceberg, and the oracular statement that an iceberg is composed of rock and earth when a witness had humbly replied, in answer to a question, that it was composed of ice, are not calculated to increase respect for the distinguished body which bears the responsibility of this investigation.*

We are not, of course, criticizing the Senator for lack of technical knowledge concerning ship construction and other lore of the ocean. It is not to be expected that even the massive brain of a United States Senator can contain detailed information on all the branches of science, art and industry. The pity is

*It may be well in order to make the record complete, to add that the House of Representatives, not to be outdone by the upper chamber, is contributing its share to increase the safety of ocean navigation. A farmer representative from Maryland has introduced a bill appropriating $100,000 for naval target practice in destroying icebergs by the guns of warships and by droping explosives on them from airships.

This will doubtless be followed by the introduction of other bills to have the icebergs towed by naval vessels into Atlantic coast cities in order to "bust the ice trust."

that the Senator does not realize his own limitations.

There are in Washington plenty of eminent experts in the government service whom he might readily have at his elbow and whose information and technical knowledge would be at his disposal for the asking. We can discern no shadow of excuse for the failure to employ such expert assistance; and this failure, we regret to say, is not only bringing the investigation into contempt before the whole civilized world, but may cause it to result in total failure in bringing home to the shipping industry the important lessons which this great calamity ought to teach.

For it is exceedingly important to the engineering world that the technical facts regarding this great disaster, which is to marine architecture what the fall of the Quebec bridge was to structural engineering, shall be ascertained, so far as the testimony of the survivors may make it possible. How many water-tight compartments were flooded? Did the water enter all of them from the original injury to the hull by collision with the ice, or did it leak from one compartment to another through overstressed bulkheads or doors not closed tight? Which compartments were flooded? Did the hull actually break in two before the final plunge, as some survivors thought? Were the sounds heard at the end, explosions of boilers, bursting bulkheads or falling machinery? What pumping capacity was available and was actually used to cope with the incoming water?

These are some of the questions on which marine engineers the world over earnestly desire information. It is probably true that the answer to some of these questions may never be given because death has sealed the lips of the ship's entire engineering force and of her chief officers. There are, however, enough survivors with more or less knowledge of the chief events during that terrible night, so that a clear-headed inquiry by experts might reveal much important information which the present investigators appear to wholly overlook.

A Floating Deck House for Ocean Steamers

Of all the many published suggestions for improved means of saving life at sea which the "Titanic" disaster has brought forward, we believe the one of greatest importance and merit is that made by Mr. Henry R. Towne in this issue of ENGINEERING NEWS. Mr. Towne's proposal is to convert one or more of the deck-houses on top of the vessels's superstructure into a water-tight pontoon, which would be left floating on the water if the vessel itself sinks, and inside of which the passengers and crew could take refuge.

This suggestion will appeal especially, we believe, to marine architects as eminently practicable. Such a structure could be used for all the purposes which the present deck-houses serve, and it would involve no great expense to build it as a separate structure instead of securing it to the vessel's hull in the ordinary way.

Of course, on cargo vessels of low superstructure such a pontoon deck-house would have to be firmly secured to the deck to guard against its being shifted or carried overboard by a heavy sea. It would be perfectly practicable, however, to provide such fastenings and at the same time to arrange for their prompt release in case of the threatened sinking of the vessel.

We believe that such a floating pontoon would offer far greater security to the lives of passengers and crew in case of the loss of the vessel at sea than the most complete equipment of life-boats and launching devices that ingenuity could devise.

It is probable that the cost of constructing a vessel in this way originally would be little if any more than the cost of building a vessel in the ordinary way and equipping it with life-boats enough for the entire ship's company. Further, the deterioration on the pontoon structure would be trifling while there is always danger that life-boat equipment, launching apparatus and tackle may deteriorate from age and exposure to the weather and prove defective in time of need.

Government Regulation of Railway Wages and Railway Rates in England and the United States

A very serious crisis was narrowly averted on Apr. 23 when Commissioner Charles P. Neill, U. S. Commissioner of Labor, and Martin A. Knapp, Judge of the U. S. Commerce Court, offered mediation under the Erdman Act between the Locomotive Engineers' Brotherhood and the managers of the railways east of Chicago and north of Norfolk. At the time when these government officials stepped into the breach and tendered their friendly offices to bring about arbitration as to the differences between the railways and the engine men, the two sides had come to a deadlock and the heads of the Brotherhood had declared their intentions of immediately tying up traffic on the railways affected.

That both sides will join in accepting arbitration of this case is greatly to be hoped. There can be no desire on the part of any right-thinking person to have repeated in this country the nation-wide paralysis which afflicted England during the railway strike of last year and which wrought dire distress in France a few months earlier. Great as are the difficulties in connection with any system of compulsory arbitration, it must eventually be recognized that the interest of the public at large far outweighs the interests of either the railway companies or their employees. Stoppage of railway traffic means inevitably business paralysis everywhere and starvation in the cities. The government, representing the whole people, has as complete a right to interfere to prevent such disastrous results as it has to combat any movement threatening to overturn the government itself.

It is of interest to see how closely parallel is the experience of the two great countries, Great Britain and the United States, which alone of all important industrial nations still retain private ownership of railways. In all other important countries of the world, including the English colonies, government ownership prevails.

In both Great Britain and the United States, a profound revolution has taken place in the relations between the railways and the public. Forty years ago, and even 25 years ago, the railways of each country, while subject to the laws governing common carriers and theoretically under certain obligations to the public, were practically permitted to do about as they pleased. The public still believed that competition should be the main reliance to secure for it good service and freedom from extortion.

Now, however, the competitive theory of railway operation has been definitely abandoned. Both in Great Britain and the United States the railways are everywhere recognized to be subject to complete public control as to all details of service and operation and as to the rates which may be charged. In both countries, moreover, this control has been put into actual operation to a very large extent.

When the great British railway strike occurred last summer the British government practically assumed the obligation of bringing forward some measure which would make possible an increase of wages for British railway employees, who, according to American standards, are miserably underpaid.* At the same time the government recognized that any such measure must not threaten the solvency of the railway companies.

	England, per day of 12 hours	U. S. per day of 10 hours
Engineers	$1.55	$4.80
Firemen	0.96	2.85
Conductors	1.21	4.11
Brakemen	0.95	2.81
Switchmen	0.94	2.80
Trackmen	0.94	1.32

On Apr. 1 the government's bill to meet the demands of railway labor was presented in Parliament. For our present purpose the interesting feature of the proposed bill is Section 2. This section provides that where any shipper com-

*According to a report made by Special Agent Ames, of the Interstate Commerce Commission, on the average wages paid railway employees in England, the average wages paid there to railway employees compare with similar averages in the United States, as follows:

plains that an increase in rate made by the railway company is unreasonable, the railway company may show "that the whole of the increase, in respect of which the complaint is made, is part of an increase of fares, rates or charges made for the purpose of meeting any increase of the railway company's expenditure due to the cost of improvements made by the company in the conditions of employment of persons employed by them." If the railway company offers this defense of an increase of its rates, then the burden of proof is on the complaining shipper to prove that the increase is unreasonable. In briefer terms, the railways are to be allowed to raise their rates if they will use this money to pay increased wages to their employees.

The close parallel between the conditions in Great Britain and those prevailing in the United States will be readily seen. As we showed last week, an increase of wages to all employees equal in percentage to that asked by the engine runners would nearly wipe out the present margin of net earnings available for dividends. There seems, therefore, no escape from the conclusion that if, under the pressure from railway labor unions, a horizontal increase in railway wages is to be made, it will have to be compensated for by permitting an increase in freight rates. To raise passenger rates would be of very doubtful financial benefit, since any considerable increase would probably reduce the volume of traffic enough to fully offset the gain in revenue which would otherwise be made.

Of course an increase in freight rates will mean an increase in cost of production in a thousand industries and a consequent further advance in the cost of living which will affect every wage earner. If railway employees' wages on the average are below the general level of wages in other industries, such an increase would be justifiable; but if railway wages were so low there would be difficulty in recruiting the ranks of the railway forces. There is no evidence that any such difficulty exists.

The "Laboratory View" of Waterproofing Concrete

In another part of this issue we devote several columns to an abstract of the recent government report on tests of the waterproofness and the waterproofing of concrete. We realize that this abstract very inadequately covers the subject to which the report itself is devoted, but we have made it mainly to convey some idea of the scope of the tests and the deductions made by the government investigators, trusting that those of our readers who are interested in the specific results will obtain from the Bureau of Standards at Washington copies of the lengthy report itself.

It is to be regretted that an investigation so detailed in its performance should be so general in its report. Forty different proprietary waterproofing or damp-proofing compounds are named in the report, their chemical analysis given and their effectiveness for the designed purpose noted by means of quantitative tests. Unfortunately the analyses and the quantitative results are not connected in the report to the respective materials tested, so that, except for the clues afforded by the division of the different compounds into generic classes, the report is of no value to the constructing engineer in determining the effectiveness of any waterproofing mixture offered him by a sales agent. It will be said, of course, that the recommendation of any particular proprietary brand —even the indirect recommendation of a successful test—is not the function of a government body, but in this report the complete analyses of the various materials are directly connected to the test results, so that anyone with enough interest to have chemical analyses made can closely approximate an identification of the different compounds. As long as such an identification is possible to the few who care to take the trouble of a chemical analysis, why not make it available to the many for whom the work is primarily intended?

One answer to that question is that the investigation, like all previous ones of a similar independent character, concludes that the best waterproofing agents for concrete are good materials, plenty of cement and careful mixing. If, as the report states, "portland cement mortar can be made practically watertight or impermeable to any hydrostatic head up to 40 ft. without the use of the so called 'integral' waterproofing materials," it is obviously useless to specify the relative efficiencies of 40 different compounds designed to reach the same end. The strange part of the matter is that there *are* 40 compounds on the market, and that most of them are bringing in a fair enough profit to their owners to warrant manufacture. Either there is lamentable ignorance of the possibilities of concrete on the part of its users or there is something radically wrong with these laboratory tests, which, it may be said, confirm practically all previous laboratory tests.

It seems to us that the divergence of views is due to the innate difference between field and laboratory work. Undoubtedly water-tight concrete can be made in the field, if laboratory conditions in regard to material and methods prevail. Undoubtedly such concrete has been made in the field where those in charge have had a proper regard for the nice adjustment of men and materials that water-tight concrete demands. The fact remains that most concrete is not made in this way, and that engineers, recognizing this fact, try to bolster up moderately good methods and materials by some one of the waterproofing compounds, guaranteed to keep the water on its own side of the wall. They may recognize, as the report in question states, that "the addition so called 'integral' waterproofing compounds will not compensate for lean mixtures, nor for poor materials, nor poor workmanship," but they do think that ordinary methods will make concrete strong enough structurally for its designed purpose and that to produce water-tight concrete these ordinary methods, which are *not* of the low grade that produces worthless concrete, need some extra frills, for which it is popularly supposed some magical included mixture will compensate.

If what we may term the "laboratory view" of waterproof concrete is to prevail, the laboratory experts must produce something more than small-size tests to impress the average concrete user. They must build some fair-sized walls with journeymen labor and stock material and compare the water-tightness of such walls, where some extra waterproofing mixture is added, with similar walls built under their optimum conditions of aggregate, mixture and men, but with no additional protection against water percolation. Furthermore, they must produce evidence that the careful precautions that they recommend are possible under ordinary field conditions of cost, materials and plant. Until such tests have an outcome favorable to the "laboratory view," and are confirmed by more general practical examples than are now known, we are afraid the sales agents for the "integral" waterproof compounds will still find a market for their wares, not necessarily because those compounds have proved effective, but because their advantages are being constantly urged upon engineers who know that ordinary concrete is not water-tight.

Near-by this office a reputable contractor is mixing concrete for one of the subways of New York City. The mixer, the materials and the methods used there presumably have to pass the inspection of a most efficient municipal engineering force. From a rather close observation of this operation for some days, we venture to say that owing to the crude method of proportioning, the aggregate in the concrete being deposited will vary in content from 10 to 20% in successive batches, even assuming a uniformity in the gravel used, which assumption would be stretching the facts. This is not an unusual case, nor is the concrete which is turned out a poor concrete, but we venture to say it is not a waterproof concrete. Such methods of laying concrete, which are common enough, will have to be reformed if waterproofing by good workmanship is to obtain.

The Hudson Bay Railway Project and the "Titanic" Disaster

As many of our readers will recall, the Dominion of Canada has taken the preliminary steps toward building a railway over 400 miles long, extending from The Pas, a point on the Canadian Northern Ry. system some 400 miles northwest of Winnipeg, northeast to a port on Hudson Bay. The sole object of this proposed railway line would be to carry grain from the wheat fields of the Canadian Northwest to a port of shipment on Hudson Bay, from which it could be taken by steamer to European markets.

In commenting on this project, ENGINEERING NEWS has repeatedly called attention to the grave dangers of navigation on the proposed route. These dangers are fully realized by the ablest engineers in Canada, we believe, and the only reason why the project has been carried forward is because it was supposed to be in the interests of the farmers of the Northwest and a political concession to them.

The Canadian public does not realize what is involved in the enterprise on which it is proposed to expend many millions of dollars of public funds. At the present time, when the public has had so terrible an object lesson of the dangers of ocean navigation in far northern waters, it seems worth while again to call public attention to the ominous risks attendant upon this projected enterprise.

It is true that so far as distance on the map is concerned, the voyage from the proposed Hudson Bay port to Liverpool would be only about 200 miles longer than the voyage from Montreal; but distance is not the main element of expense in ocean navigation. Danger is an element equally to be reckoned with. Losses by sea are translated by the marine underwriters into insurance rates. We are strongly of the belief that if the Hudson Bay Railway were built and if grain-carrying ships were to attempt to ply back and forth to Hudson Bay ports to carry its traffic, the percentage of loss would be so heavy that the marine-insurance rate alone would make it impossible for the route to compete with other routes as an outlet to Europe.

It should be clearly understood that at present there is no traffic whatever over this proposed route. Only the ships of explorers and the small craft used by seal hunters, whalers, etc., navigate the northern waters at the entrance of Hudson Bay. Probably few, even among engineers, realize how serious are the ice conditions in Hudson Bay itself, even in late midsummer. To give a clear picture of just what these ice dangers are, as well as of other dangers to navigation, we reprint below an extract from a recent official report made to the Canadian government by its Naval Service Department, describing the voyage of a vessel which was detailed to explore the Hudson Bay route to gain light as to its practicability. This document will repay the careful study of Canadian engineers, at least, to whom this proposition to spend many millions of dollars of government money must certainly be of interest.

From the Annual Report of the Department of the Naval Service; Aug. 8, 1911.

Owing to the proposal to build a railway from some point in the Canadian Northwest to Hudson Bay, this survey was instructed to make an examination of Ports Nelson and Churchill with a view to reporting upon them as desirable termini for railways, or rather whether or not they can be made ports to be used with safety by ocean-going vessels.

For this purpose two parties were organized. For transporting these parties to the localities the Department of Marine and Fisheries kindly loaned us the ice-breaking steamer "Stanley," which was placed in charge of Commander I. B. Miles. He had as officers, Captain Dalton, of the "Stanley," and Captain S. W. Bartlett, one of the best known pilots for Hudson Strait.

He furnishes the following interesting report on the trip, particularly on the ice conditions met with:

Ice conditions. Great numbers of icebergs were met with along the Labrador coast. These bergs are reported by fishermen to be much more numerous from the coast to 20 or 30 miles off than farther out. Probably the best course for a vessel, making from Newfoundland to Cape Chidley, would be about 50 miles off the land.

Cape Chidley was rounded and Gray Strait entered at noon on July 18, the ship anchoring in Port Burwell at 3 p.m. the same day.

Port Burwell and the bays along the coast were found to be quite clear of ice, but in Ungava Bay, as far as could be seen from aloft, the ice appeared solid. From information obtained from the Mission at Port Burwell, this field has been held in Ungava Bay by a long period of light northerly winds. It also appears that this year the ice in Burwell and adjacent bays had broken exceptionally early (about July 10), but as a rule it may be taken that it is impossible to enter these harbors till the last few days of July. In 1909, on the day corresponding to that on which I entered Port Burwell, dog teams were still crossing the harbor on the ice.

On leaving Port Burwell, July 19, heavy field ice was encountered at a distance of about 30 miles. This had apparently set out from Ungava Bay and drove the ship a considerable distance north toward Resolution Island. The extent of this field was about 60 miles, after which a sheet of comparatively clear water was passed through until 10 p.m. of July 20, when very heavy ice was met with. This kept the ship to the southward and made it necessary to abandon any idea of making Ashe Inlet.

In the opinion of Captain Bartlett this was Arctic ice, being much heavier and dirtier than that from Ungava Bay.

This pack appeared to be continuous from the northward to within a couple of miles of the southern shore of Hudson Strait (Cape Prince of Wales to Digges Island), a narrow passage along the shore being apparently kept fairly clear by tidal streams.

After a short spell of clear water off Cape Digges, about 40 miles of heavy ice drove the vessel toward Nottingham Island.

Mansfield Island having been passed, the southern point of Coats Island was steered for and course set for Churchill.

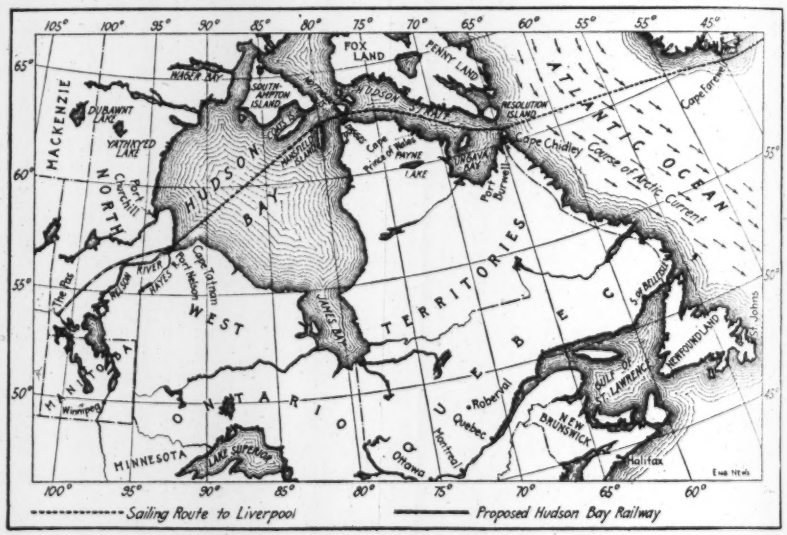
Toward evening on July 22, the ship struck the outer edge of the largest ice field met with on the whole voyage. This, for a distance of about 200 miles, was continuous. This ice was not very heavy for a vessel specially constructed, but called for considerable skill on the part of Capt. Bartlett, the ice pilot, in finding leads.

There being no indication of clear water on either side, it was resolved to make as direct a course as possible. The ship was seldom stopped, but was heavily shaken by the continuous pounding necessary to force her way through.

This field was suddenly cleared on the morning of July 24, and Churchill was reached the same night without further delay.

Churchill and Nelson having been visited, the vessel left the latter place on the evening of July 30, on the homeward voyage. Within a few hours of leaving Nelson the heaviest ice yet met was encountered, and for about 90 miles very slow headway was made. This having been cleared, nothing but light ice was met, either in the Bay or Strait, until after leaving Port Burwell. While at anchor at Port Burwell awaiting the arrival of the "Earl Grey," the ice set out of Ungava Bay before a moderate southerly breeze, and Burwell Harbor was completely filled. The ice was, of course, loose, but made boat work impossible at times.

Port Burwell was left upon August 9, and within an hour the ship for the first time encountered ice that stopped her. This had evidently been heavily packed in slack water, the flood carrying its own ice to meet that returning through Gray Straits on the ebb. When the strength



MAP OF PROPOSED HUDSON BAY ROUTE TO EUROPE

of the tide made itself felt, the ice holding the ship was loosened and by keeping close along the southern shore of Gray Strait, Cape Chidley was rounded and course set for southward. The pack was apparently very heavy up to the Button Islands.

Very few bergs were seen on the return along the Labrador coast.

While numerous bergs were met with in the eastern part of Hudson Strait, none were seen in Hudson Bay itself, and Capt. Bartlett informed me they are practically unknown there.

It would appear from the above remarks that vessels may expect to meet ice from Cape Chidley to Churchill, but Capt. Bartlett's opinion was to the effect that our experience was exceptional, and that a long spell of light winds had contributed to the packing of the ice. Personally, I cannot see why this should be so, as the ice forms and breaks away year by year, some years (as the present, 1910) exceptionally early, no doubt, but it must be met some time during the navigation season. Long spells of wind in one direction might hold it in the bays and inlets for some time, but it is not likely that these winds would be so continuous as to keep it there until frozen in again. Therefore, any vessel navigating the bay must be prepared to meet ice. While none of that met with on this voyage could have been dangerous to the "Stanley," or sealers and other specially constructed vessels now trading in the district, I am of the opinion it might be dangerous to a ship not so built. I certainly do not think any cargo vessel of ordinary construction would have been able to find or force her way through the large field met before Churchill, but would have been obliged to remain in the ice until it was loosened by winds or currents.

Under the weather conditions which prevailed while the "Stanley" was in the bay, a ship might wait an indefinite period for the ice to open up again. In the event of a strong breeze which would eventually disperse it, the preliminary would be a heavy packing to leeward, which might jeopardize the vessel.

Throughout the above remarks "ice" is to be taken to mean ice fields and not bergs.

WEATHER CONDITIONS

The "Stanley" was exceptionally fortunate in weather while in Hudson Bay and Strait, nothing more than a moderate breeze being experienced. But, as a general rule, in the strait and bay proper, no lasting heavy weather need be anticipated during July and August, although in the vicinity of Nelson River, heavy "northers" in August are reported by the Hudson Bay vessels, sometimes lasting from 36 to 48 hours.

A considerable amount of fog was met with, which would be expected with the light winds prevailing during the voyage. This fog was usually in the vicinity of ice, but not necessarily so.

Temperatures in the bay and strait were not low, the air averaging between 31° and 40° F., sea water between 30° and 40° F.

Owing to the uniform temperature of the water, little can be judged from this as to the vicinity of ice. This was also noticed after clearing the Straits of Belle Isle, that is to say, that the colder currents having been entered, the proximity of even large bergs made little difference to the temperature of the water.

GENERAL NAVIGATION

As the whole of the Hudson Bay chart appears to be more or less in the nature of a sketch or running survey, great caution would naturally be exercised by the ship masters in making land.

From my experience on this voyage, the land and islands are in some cases 15 to 20 miles out of longitude. In any case it would be unwise to attempt to make any land except in daylight and clear weather.

The Button Islands, southern shore of Gray Strait, and the land between Cape Prince of Wales and Digges Island, as shown on chart, bear little resemblance to the actual coast. King and Joy Islands do not exist, and Charles Island lies much closer to the mainland than the chart shows.

COMPASSES

As regards the great "bugbear" of Hudson Bay navigation, the reported local attraction and inaccuracy of the compass, I found nothing to justify this evil reputation. In one or two places only, and when in close proximity to the high land (Cape Chidley and Cape Digges, for instance) I found a deviation of two or three degrees from the normal.

Being exceptionally fortunate in having clear sun and stars, my observations for error were almost hourly, and showed that the change of variation, though rapid, was normal, but the lines of variation will not quite agree with those shown on Admiralty charts. For instance, the line of "no variation" lies about 30 miles east of that shown on chart. As stated above, the proximity of the magnetic pole (and consequent small value of horizontal force) renders the needle sluggish and an alteration of a few degrees in direction of the ship's course is not immediately shown by the compass.

PORT NELSON

Until the results of the detailed surveys are in, it is difficult to give an unprejudiced opinion as to the relative values of Fort Churchill and Port Nelson as ports, and I can only take the point of view of a master of a vessel making these places for the first time without local knowledge or pilot's assistance.

The land in the vicinity of Cape Tatnam and the western shore is very low, the summit of the trees being certainly not more than 50 ft. above H. W. The ground on the approach to Port Nelson or York Roads was found to be very foul.

Four fathoms of water was picked up with no land in sight, and eventually anchored in nine fathoms in a position where the trees were only visible from aloft, and a beacon which is situated near the entrance to Hayes River and the summit of which is 80 ft. above H. W., was just visible from the ship at a height of 40 ft. above the water. Although only 80 ft. high, this beacon can be seen some time before any other sign of land is visible.

The current from the Nelson and Hayes Rivers is very swift, a great volume of water being discharged into Nelson Roads. When this current combines with an ebb tide and sets against the heavy northerly gales which prevail here in August and September, a very bad sea is raised, especially, as may be imagined, inside the five-fathom line of soundings. The Hudson Bay vessels have found much difficulty in making, and holding, their positions in Nelson Roads, and on more than one occasion have been obliged, after waiting some days for favorable conditions, to abandon all idea of discharging. They have then carried their cargoes on to Churchill, from whence it had to be drawn by dog teams during the winter. The usual procedure for the Hudson Bay vessels is to close the land as much as possible on the rising tide, and on their signals being observed by officials ashore, to steam out and anchor at a distance of about 18 miles and await the boats.

In August, 1909, one of these vessels experienced a northerly gale of 48 hours' duration, during part of which time she was steaming full speed with both anchors down, with a heavy sea breaking on board. After remaining in the vicinity for ten days, and being unable to work, she proceeded to Churchill and there discharged her Nelson cargo.

After leaving Port Nelson anchorage I sounded my way out to the northeast and carried good water for some miles until, at an estimated distance of from 12 to 15 miles from Cape Tatnam, I suddenly picked up 10 fathoms and thought it advisable to haul due north. The ground in the vicinity of Cape Tatnam is reported locally to be as foul as that on the western side of Port Nelson.

As a result of Mr. Parizeau's survey at Nelson River I beg to offer the following report:

The work on the survey of Port Nelson was carried on during the season of 1910 from the three-masted schooner "Chrissie G. Thomey," purchased in Newfoundland especially for the work. It was in command of H. D. Parizeau, who was assisted by R. F. Fraser.

Owing to the great difficulties encountered very little surveying that can be placed on paper was done. The greatest labor was necessary to get ashore with material for signals and owing to the low beach these had to be large and high that they might be seen a few miles off. The winds and seas were very heavy and in the exposed situation working from even a large well covered-in launch was impossible.

At a point 15 miles from the beacon on Marsh Point and the same distance from Sam's Creek, there is a depth of only ten fathoms. The water toward the river gradually shoals and the river channel develops until at a point midway between Marsh Point and Sam's Creek, a bar is reached over which not more than 21 ft. can be carried. Here the channel at low water is about 600 yd. wide, the banks on either side drying at low water. Inside, the channel deepens again and continues for seven miles to the position selected for the outer wharf, where only 17 ft. of water can be found and the channel is about 600 yd. wide.

Observations for tides show that springs rise 16 ft. and neap 10 ft., and the tides flow and ebb at from 2 to 3 knots.

There is one thing certain that the survey is no child's play, the roadstead is exposed to every wind that blows and every sea that runs, the currents and cross currents are strong, the shores so low that nothing can be seen from boats and all locations must be determined from the previously ascertained position of the ship.

Ice began to form, coming down the river on one tide and up on the next, on Oct. 31, and gradually became worse, each day making navigation more hazardous.

Until further and proper definite information is obtained, no opinion can be expressed as to the suitability of this port for a terminus.

On Sept. 12, it was decided to send the schooner to Halifax and continue the work from camp until the ice would render moving about dangerous.

The schooner therefore sailed, arrived at the western entrance to Hudson Strait on Sept. 15, and at the eastern entrance on the 21st, having experienced strong gales and snow storms and thick weather, almost all the way. Twelve icebergs were seen off Ungava Bay. The vessel reached Brigus, Newfoundland, on Oct. 7.

It is worth especial notice that according to the records of this voyage, a special ice-breaking steamer in late July and early August had to steam through field ice for a large part of the distance across Hudson Bay. At times the vessel was driven a considerable distance out of her course and she had to search for leads through the ice like an Arctic exploring vessel in order to find passage. At times she was held fast by the ice and was unable to proceed at all.

The report states explicitly that any cargo vessel of ordinary construction would not have been able to navigate the ice fields as did the "Stanley." Not only is ice a continuous source of danger and obstruction to traffic, but fog is present, as might be expected, a large part of the time, and the combination of ice and fog makes navigation inevitably dangerous.

It will be understood, of course, that the ice encountered by the vessel in Hudson Bay itself was field ice, or the ice resulting from the breaking up in the spring of the frozen surface of the bay. The greater danger in navigation, however, comes from icebergs. These are huge masses of ice which are detached from the glaciers along the coast of Greenland and the shores on the west of Baffin Bay and drift southward in the Arctic current.

The report states that "numerous bergs were met with in the eastern part of Hudson Strait." We have shown on the map by small arrows the course of the Arctic current, which moves from Davis Strait and the coast of Greenland down into the north Atlantic, and we have traced across it the probable route of ocean vessels sailing from English ports to or from Hudson Bay. It will be seen from the chart that for several hundred miles before reaching Hudson Strait a vessel is at any time liable to encounter icebergs. The "Titanic" met its fate by running into an iceberg in latitude 41° 46′, or nearly as far south as the latitude of Providence, R. I. But a vessel sailing on a great circle course from Liverpool to Hudson Bay would sail across the north Atlantic to the southern extremity of Greenland in latitude 60° and then directly across Davis Strait to the mouth of Hudson Strait. In making this latter passage it must encounter, much of the time in foggy weather, the stream of icebergs moving down from the Greenland coast.

Against this danger it is impossible to guard. No one will now claim that it is possible to make vessels unsinkable, even the expensive class of vessels designed for passenger service. Economy requires that the cargo carriers built for carrying grain shall be constructed at the lowest cost permissible with reasonable security against the peril of storm and waves.

In southern waters it is *sometimes* possible to detect approach to an iceberg by the temperature of the water, but as pointed out in the above quotation from the Canadian government's official report, in these cold Northern waters the normal temperature is so near freezing that no warning of approach to floating ice can be gained in this manner.

At best, the season of navigation by the Hudson Bay route would be very short. From the middle of July to the middle of October, three months' time, would be as long as could reasonably be expected; and this period is just about the period when the bergs loosened from the Greenland glaciers during midsummer would be brought down to float across the sailing route, propelled by the Arctic currents.

In a report on the Hudson Bay project, made by M. J. Butler, when Deputy Commissioner of Railways of Canada, he assumed that the business done by the Hudson Bay Railway in moving grain to market would have to be concentrated in 30 days of the year, say the month of August. With 32 trains, each capable of carrying a train load of 4000 tons, Mr. Butler estimated that during 30 days 64,000,000 bushels of grain could be moved over the railway to the Hudson Bay terminal. To move this enormous amount of traffic from the terminal, at least nine ships per day would have to be loaded, and allowing two trips per season for each vessel, it would take over 140 ships to move the traffic.

As a practical matter, however, it is extremely doubtful whether it would be possible to harvest and thresh the wheat crop of the Northwest, which matures late in that far Northern climate, transport it to railway stations, collect it from the various railway lines, deliver it to the terminal at Port Nelson, load it on board ship and start it on its journey to Europe, all before the first of September.

It is probable that even barring all matters of safety, it would not be possible to harvest and deliver more than a very small percentage of the annual wheat crop during the short period of navigation. This means that, in order to go to market by the Hudson Bay route, one season's crop would have to be stored until the next season before shipment. The cost of this storage adds another handicap to the Hudson Bay route as an economical means of transport.

Mr. Butler, in the report to which we have above referred, estimates the total possible saving that could be made by the Hudson Bay route to Europe over the Montreal route at 5c. per bushel. In view of the facts above recited, however, it appears that the cost of the extra marine insurance on this far Northern and very risky route, added to the cost of a year's storage of a large part of the season's crop, would much more than overbalance this possible estimated saving by the Hudson Bay route.

We have thus far considered from the cold-blooded dollars and cents point of view only, the question whether the risk represented by marine insurance on this Northern route would overbalance the possible saving due to the shorter rail haul. At the present time, however, when the civilized world has had its sympathies aroused to an extent seldom before recorded, it is proper to call attention to the great risk of human life involved in the attempted establishment of a route for commerce where such perils are to be met.

To send 150 vessels or more a year sailing back and forth during the season of greatest fog and ice danger through these Arctic waters would inevitably mean an annual heavy toll, not in vessels alone and in valuable cargo, but in the lives of men. Without doubt commerce will go wherever profits are to be gained, and men will be found to man vessels wherever owners are willing to risk them; but even though profits were certain, humanity protests against such serious jeopardy to the lives of thousands.

Let it be clearly understood that it is not some commercial organization, seeking to earn dividends, which is responsible for the proposed establishment of this dangerous Hudson Bay route. Its risks are such that no intelligent body of bankers or business men would be willing to invest their money in it. Ordinary business prudence would forbid them from engaging in such an enterprise.

It is the people of Canada who are proposing to establish this route, in the belief, which we have clearly indicated above to be an erroneous one, that they can thereby gain a higher market price for the wheat products of the Northwest.

Repeatedly in these columns we have sounded the warning that the $60,000,000 or more which would be required to build and equip the Hudson Bay Ry. and its terminals would be a dead loss to the taxpayers of Canada. There is now to be added to this consideration the undoubted fact that the attempt to establish this route would mean an annual toll of lives from the crews of vessels navigating these dangerous Northern waters probably at least equal to the loss of life in the "Titanic" disaster. Surely, in the face of these considerations, it is time for Canada to pause and make serious inquiry before proceeding further with this hazardous enterprise.

Safety Pontoons for Ocean Vessels

By Henry R. Towne*

Steam and electricity have profoundly modified our physical environment, and nowhere more than at sea. While they have involved us in many new dangers, they have also given us many new provisions for safety or protection. Strangely, however, this latter statement does not hold true as to conditions at sea. While speed and comfort have vastly been increased and the danger of shipwreck greatly reduced, the provisions for saving life in case of shipwreck are no different in kind, and little better in degree, than in the days of Columbus.

Life-boats may save the passengers and crew of a sinking steamship from drowning, but they may also subject many of them, especially women and children, to a more cruel death from exposure or starvation. Surely it is not beyond the power of modern science to mitigate, if not to eliminate, these conditions, at least as to the great ocean liners and upon the ocean highway between New York and Europe.

In a letter dated Apr. 20, published in the New York *Times*, of Apr. 25, I pointed out one method by which these most desirable results might be accomplished. That letter, which is reproduced below, purposely omitted all discussion of technical details.

To the Editor of the "New York Times":

Undoubtedly the "Titanic" disaster, the most appalling of its kind in the history of the sea, will lead to legislation in this and other countries compelling ships to have provision whereby all of the persons they carry can be cared for in the event of the foundering of the vessel, but thus far the discussion of means to this end appears to have been limited to the question of life-boats and rafts.

In venturing to suggest the consideration of another kind of provision, I may mention that during several of my earlier years I was engaged in marine engineering, and had charge of the installation of engines and other machinery in United States vessels of war in the navy yards at Boston, Kittery and Philadelphia, and thus had opportunity to become familiar with some of the conditions involved.

Life-boats are, and always will be, a necessary part of the equipment of a sea-going ship for use in case of need in transferring the passengers and crew to another ship or to the shore. For this purpose, for use as ferries, the equipment now usually carried is probably adequate. To accommodate at one time the entire complement of persons on board it is utterly inadequate, as the "Titanic" disaster lamentably demonstrated. For the latter purpose is not some other and better provision not only desirable but practicable? I believe that it is.

Forward and aft of the funnels or smokestacks of a steamship is a long stretch of upper decks approximating one-half of her total length. A considerable part of this space is usually devoted to the smoking room, ladies' saloon, the café, and similar luxurious provisions. Without abolishing these, but perhaps at some sacrifice of luxury and elegance to utility and safety, could not the spaces they occupy on the higher decks be utilized for the purpose in view?

Let us suppose these to be consolidated into two chambers or compartments—one forward and the other aft of the funnels. Let us suppose that each of these compartments is built as a floating pontoon, detachable from the other superstructure of the ship, held by heavy chocks or in a cradle against all lateral movement, but free to move vertically by its own buoyancy if immersed in water. Would not these pontoons constitute a safe refuge for all on board until relief arrived?

Each pontoon should have an interior height of 10 to 15 ft., and be available normally for daily use as one of the passenger saloons. Its construction would be adequate to resist the strains to which it would be subjected when afloat, with the dead load massed near the center to give stability. It would be entered by one, or possibly two doorways, and lighted by numerous portholes, all arranged to be quickly closed against water, like other similar openings now in use.

Collectively these pontoons should accommodate all the passengers and crew, who, in case of need, would be collected therein, and all openings thereupon closed. As the vessel sank the pontoons would float off. Even if drawn under the surface by suction, they would quickly rise. Each should have one or more ventilating shafts like those of the submarine boats, closing automatically when immersed. A ventilating fan, driven by a storage battery, would be feasible and helpful. Naturally water and food should be part of the equipment. Probably a wireless telegraph of moderate range would be feasible. The remaining mechanical details will suggest themselves to engineers and shipbuilders, and involve no insuperable difficulties.

The advantages which these pontoons would offer over open boats are obvious. Those within them would be protected against the elements, and would be assured of water and food for a reasonable period. It is safe to assume that the C. Q. D. signal of distress would have been flashed forth by the sinking ship before her end, and that before many hours one or more rescue ships would arrive. Meantime the pontoons would float safely, and their occupants would be guarded against extreme hardship. If built solely for this purpose, and unburdened by decorations and luxuries, such pontoons would add little to the dead load of a ship.

The average weight of a human being is less than 150 lb., or for 1000 persons, 150,000 lb., or 75 tons. Adding to this the necessary dead weight of the pontoon in its simplest form, a displacement of from 300 to 400 tons would probably suffice, but a much greater displacement would be feasible and desirable. The weight of structure thus implied would be little greater, possibly no greater, than the structure it would replace on the upper decks as now built. At most the difference, if any, would imply a trifling reduction in the cargo carrying capacity of the ship. The proposition is not chimerical, but thoroughly practicable. As such it should have serious consideration in connection with the plans for the protection of life at sea, which undoubtedly will be adopted as the result of the loss of the "Titanic"

In now submitting the proposal above set forth to the consideration of readers of Engineering News, it seems expedient briefly to discuss some of the chief technical questions involved.

Obviously the first and chief of these is that of ventilation. Taking the accommodation required for 1000 persons as a basis, the facts are as follows: Assuming the interior height of the pontoon to be about 15 ft., and that 3⅓ sq.ft. per person of floor area is the minimum which would suffice, we obtain 50,000 cu.ft. of contents: 600 cu.ft. per hour, or 10 cu.ft. per minute may be assumed as the minimum supply of air per person, which would suffice to maintain life without permanent injury. This implies, for 1000 persons, a supply of 10,000 cu.ft. of air per minute, and this in turn a motive force of about 5 hp. to operate the ventilating fans. Obviously this power could easily be furnished either from storage batteries or by oil engines of the automobile type.

Investigation shows that if berths or bunks, each 6×2 ft., were arranged in tiers from floor to deck or roof, and four longitudinal lines of such berthing were provided, the floor area so occupied would be less than for an equal number of persons standing. Such a provision would obviously be desirable. Increasing the floor area to 3⅓ sq.ft. per person, the dimensions of a pontoon to accommodate 1000 persons would be, say, 40x84 ft., although the proportion of length to width may be modified as found expedient. To accommodate the 3000 people which a ship like the "Titantic" might carry, would thus imply a total area of 10,000 sq.ft., which might be divided into two, three or four units, as would best harmonize with other conditions. If the width or beam of these pontoons were fixed at 50 ft., the aggregate length would thus be 200 ft. On such a ship a greater area is already occupied by deck structures which these pontoons would replace.

The displacement of each pontoon would amply provide for the additional machinery required for a wireless telegraph equipment of moderate range, and for the carrying of water and food stores sufficient for a limited time during which they should be needed. No propelling power is called for, but on the contrary would be inexpedient. The location of the wreck having been communicated by wireless to other ships, it would be better that the pontoons should not change their location except by the ocean drift, the direction and speed of which would be known to the rescuing ships.

*Past-President, American Society of Mechanical Engineers, President Yale & Towne Mfg. Co., 9 Murray St., New York City.

Experience has shown that the modern large steamship when fatally injured sinks slowly. This would afford ample time in which to assemble the passengers and crew in the pontoons (except possibly a portion of the crew which might be assigned to life-boats as scouts), and to close the doors and port-holes. It also implies that each pontoon as it became immersed would automatically release itself and float away.

The construction of the pontoon should be such that even if it were drawn under the surface by the suction of the sinking ship, it would take in no water and therefore would rise again to the surface within a few minutes. Even in case of the loss of a ship by fire, substantially the same conditions would obtain, and the sinking of the ship might deliberately be accelerated in order to control the fire and more quickly to release the pontoons.

All of the remaining technical details which the plan involves are relatively simple and within the familiar experience of marine engineers and ship builders. In the designing of a new ship, the incorporation of "Safety Pontoons" would involve no difficulties and probably would entail little, if any, additional cost. In the case of many, if not all, existing vessels, it would be possible to remodel their upper works, so as to incorporate these pontoons, if this change were deemed advisable.

The interior of each pontoon would be as available for normal daily uses as the present superstructure of the ship, which they would replace, and a reasonable amount of interior decoration could be adopted without at all impairing the efficiency of the pontoon for their ultimate purpose in case of disaster. It would even be possible to include in the emergency power equipment, provision for moderate lighting of the interior. In the heavy sea the hatches in the deck or roof of the pontoon would need to be closed, but in a moderate or smooth sea, if protected by proper combings, they could be opened and at times the occupants of the pontoon could safely emergy upon the upper deck, which, of course, would be surrounded by a proper railing. The pontoon would thus be simply an "Isle of Safety," in or on which the passengers and crew could remain during the few hours which elapse before the arrival of succor, whereupon they would be transferred by life-boats to the rescuing ship or ships.

If the reasoning thus presented shall prove to be sound, is it unreasonable to ask that this means of providing for the better protection of life at sea shall be considered seriously by those responsible for the equipment and management of the ocean steamship lines plying between New York and Europe?

Light Reinforced-Concrete Wharves, Madras, India*

By F. J. E. Spring†

At the Port of Madras, India, the problem had to be faced of providing some form of cheap, shallow wharfage for lighters, of such a design that it might be possible, at some future time, easily to remove it and perhaps to use the greater part of the materials elsewhere. The accommodation available for harborage purposes of all sorts at Madras, at present, consists of, first: the main artificial harbor 200 acres in extent; secondly, a 9-acre boat-basin for shelter of the Port Authority's own 900-ton suction-dredge and 500-ton bucket-dredge and smaller craft, as well as for the mercantile fleet of lighters; and thirdly, a 2-acre timber-pond. Most of the lighters are 40-ton craft, drawing up to 5 or 6 ft. of water, but some of them run up to 100 tons.

Three kinds of wharf are now in use, namely, the A design (Fig. 1) for a depth alongside, at low water, of 6 ft. and a height above low water of 10 ft.; the B design (Fig. 2) for a depth of 8 ft. and a height of 6 ft.; and the C design, similar to B, but for a depth of 4 ft. and a height of 6 ft. The A design is in use for a length of 1460 ft. in boat basin and in the main harbor; the B design is in use for a length of 1820 ft. in the boat basin; and the C design is in use for a length of 1420 ft. in the timber pond. It must be explained at this stage that the ground to be dealt with throughout is pure sand at the depths to which the wharves have to be founded. This makes it possible to deal, by means of water jets, with the piles and slabs of which the whole of the wharves are formed.

The wharf design consists of reinforced-concrete piles, driven at intervals of 10 ft. in the case of the A and C designs, and of 8 ft. in the case of the B design, and held back by 30-ft. steel ties, anchored adequately at their rear end well behind the possible plane of cleavage. The ties are formed of double-headed 50-lb. rails for the two light designs, and of 3-in. diameter round steel bars for the A design. All ties are thoroughly bedded in concrete boxed around them, and their heads, where they pass through the piles, are well cemented up. The anchors for the B and C designs consist of a pair of railway pot, or bowl, cast-iron sleepers; those for the A design are of reinforced concrete. It is proposed to open up a certain percentage of these ties and anchors annually in order to correct any tendency to corrosion. This can be done quite easily without interruption of traffic, by watching for convenient opportunities.

Against the back of the piles are reinforced-concrete slabs. The A design has three superimposed slabs, and the B and C designs each have two slabs. The bottom or cutting-edge of the lower slab is chisel-edged, or beveled, so that, in sinking, it may tend to draw up against the piles. The slabs have been suitably designed for the pressure against them, in order that, as girders, they may resist bending and shearing; the piles, too, have been similarly designed, as also the ties and the anchors. The conditions for this design were: Weight of sand, 120 lb. per cu.ft.; angle of repose with horizontal, 25°; plane of rupture (angle with vertical), 32°.

The coping along the top of the wharfage is formed of a couple of 50-lb. double-headed rails, bolted together and concreted up with the slabs and piles. Small bollards, suitable for use by the class of lighters using the wharves, are formed, as shown, by small pieces of bent rail embedded in the coping. In the case of the A design each pile has a cast-iron cap on top. In the B and C designs the piles are connected by reinforced-concrete jack-arches, in one mass with the slab and with the coping, as shown in Fig. 2. All are timber-fendered on the face.

Where hydraulic cranes stand at the back of the wharves—and of these there are 20 so placed on the A wharves—each crane is mounted on four piles, similar to the wharf piles, but only 15 in. in diameter and quite independent of and in rear of the wharf; these can be seen in Fig. 1.

Just as the slabs and the piles can be sunk by a water-jet, so if ever necessity arises they can be removed by the same method, for use elsewhere. Of course, this means the scrapping of arches and copings, as well as of part of the concrete of the embedded ties, but it is a great gain to be able to save some of the material. The fact is, in so poor a port—liable all the same to cataclysmic acts of generosity at the hands of a paternal government—there must ever be borne in mind the chances of having to dismantle large quantities of such work—of a quasi-temporary character, and put in for a few years' use for the sake of immediate cheapness—in order that expensive quays, or peradventure even docks, may be erected later.

Instead of describing the mode of erection of the B and C designs, which was comparatively easy because of local conditions, that of the A design may be usefully described. The work begins at one end and goes forward toward the other end—except for accidental interruptions—at the rate of (more or less) three piles and their corresponding slabs per week. The whole of the material is handled by a 5-ton hand crane, which stands on a

*Abridged from Paper from Minutes of Proceedings of the Institution of Civil Engineers, vol. 186, 1910-11, part IV.

†Chairman, Harbor Trust Board, Madras, India.

group of 6-in. screw piles forming a platform in the rear, in the water of the harbor. This platform or staging is always kept moving forward by its rearward piles being shifted to the front. The piles in this false-work are not screwed, but are water-jetted when their removal or erection becomes necessary, the water-jet being also at hand for the sinking of the reinforced-concrete piles and slabs. If the water in which the latter piles and their slabs stand becomes too deep for them to be left in safety prior to the insertion of the ties and the filling in at the back, the Port Authority's suction dredge very soon shallows up the site through its line of floating pipes. If, on the other hand, after completion of the wharfage, the depth in front is found to be too shallow for the craft using it, the bottom is leveled all over to a suitable depth by means of an extemporized suction dredge for use in small depths, consisting of a scow or barge rigged for this purpose, and carrying a 10-in. centrifugal pump driven by an engine.

At first, before the workmen became skilled in lowering slabs so as to bear accurately against the backs of the piles, and also wherever a pile was left slightly out of line or had become crooked, or again, where it had received a twist during manufacture, the earth filling behind the wharf used to cave in whenever heavy rain fell. But by always filling such hollows with engine ashes, and later, by depositing ashes behind all the piles, it was found that the sand was no longer sucked through the small openings between the slabs, or between the piles and the slabs. Such openings soon become filled by the engine ashes which stick in them, and the sand thereby ceasing to flow, caving-in ceases also.

The water-jet for sinking the slabs and piles is obtained from a 10x10x10-in. or a 6x7x6-in. duplex pump, driving water through a 6-in. pipe from which 1½-in. jets are taken by flexible fire hose. When a slab is being sunk, a kind of rake made of five 1½-in. pipes keeps the sand it must pass through in a state of sloppiness, and the slab sinks through it "like a hot knife into butter." The A piles are 18 in. square and the corresponding slabs are 12 in. thick, though the top slab where it has not the back pressure of the water to aid it is increased to 15 in. thick as shown.

One of the 12-in. slabs was tested, on a clear span of 8 ft. 6 in., by a central load equivalent to a uniform load of 3383 lb. per sq.ft., without breaking. Under this load, which was about four times its designed load, it deflected ½ in., and on the removal of the load recovered itself ¼ in. On being similarly loaded a second time it deflected the same amount (½ in.), and again recovered ¼ in. when the load was removed. For the B and C designs, piles 15 in. square and slabs 6 in. thick were used. One of the 6-in. slabs was tested on a span of 6.75 ft. under a distributed load of 1415 lb. per sq.ft. without failure. The concrete was made with ¾-in. broken granite in the proportions of 1:2:4.

The actual cost of the three kinds of wharf has worked out as shown in the table below, including fendering:

The Port of Madras is essentially a lighterage port, as distinguished from a ship-quay port. Most of the vessels calling there are *en route*, either to the terminal port Calcutta, or back from that port to Europe, and they usually put out or take in cargo in amounts of only 100 to 4000 tons at Madras. The chief consideration, therefore, is that such vessels should be given all possible opportunity for the rapid discharge or embarcation of their cargoes, and that the shore facilities should be fully able to keep pace with a vessel's own derricks, even when six to ten vessels are all working at one time. There are some 4700 lin.ft. of reinforced-concrete wharf such as has just been described, equipped with 25 hydraulic and six hand cranes, of from 1 to 3 tons capacity. Added to this there are about 1800 ft. more of screw-pile jetty-face, equipped with 26 hydraulic and as many more steam and hand cranes; also 2000 ft. more of harbor arm, used largely for coal and heavy cargo, with cranes of 33 tons, 30 tons and 15 tons, and a number of smaller ones. These facilities—nearly the whole of which have come into existence in the last five years—make Madras, or in a few months more will have made it, one of the fastest ports in the East for vessels to work in, especially now that, since 1909, a fleet of modern lighters and tugs has sprung into existence; the result of the construction of the 9-acre boat basin.

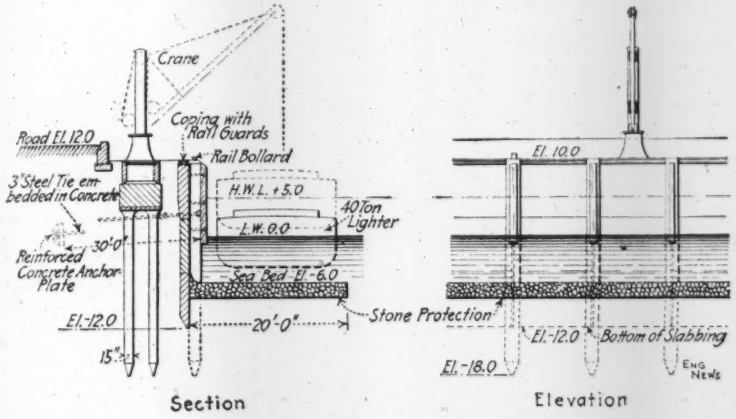


FIG. 1. DETAILS OF "A" TYPE OF WHARF, MADRAS, INDIA

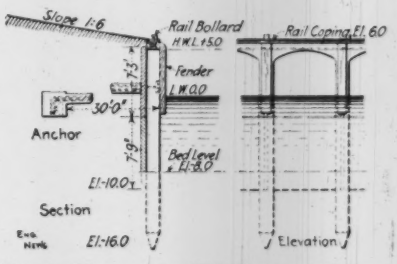


FIG. 2. DETAILS OF "B" TYPE OF WHARF, MADRAS, INDIA

Revolving Switch Rails are the feature of a track switch invented by E. D. Brown, of Kalispell, Mont., and the details of the design have been worked out by Woodmansee, Davidson & Sessions, engineers, of Chicago. Each switch rail is of cylindrical section, riding in fixed bearings, and having longitudinal grooves to form the flangeway. The position of the switch is changed by giving the switch rails a quarter turn on their axes, this being effected by suitable connections to any ordinary form of switchstand or to a special switchstand designed for this particular use. The switch rails are locked to the stock rails in either position. As to snow and obstructions, it is claimed that these will either fall out of the groove by the movement of the rail or will be knocked out by the wheel flanges. A 15-ft. switch of this type has about ⅛ in. divergence at 3 ft. from the point (as against 1½ in. for a split switch), and 4½ in. at the heel; this gives a turnout curve of 285 ft. radius. It is stated, however, that a switch with 9-ft. cylindrical rails will have about the same angles as a split switch with 15-ft. rails.

Class	Depth at low water Ft.	Height of quay above low water Ft.	Spacing of piles center to center Ft.	Height from bottom of piles to top of quay Ft.	Side of pile In.	Thickness of slabbing In.	Cost per lin.ft.
A	6	10	10	28	18	12 to 18	$31.46
B	8	6	8	22	15	6	15.73
C	4	6	10	18	15	6	11.26

A Locomotive Boiler Exploded Apr. 9 at Stanwick Station, 100 miles east of Yuma, Ariz., on the Southern Pacific Ry. Reports state that the engineer was killed and the fireman perhaps fatally injured. The locomotive was attached to a freight train.

A similar accident with the same casualties wrecked a locomotive on the Chicago, Indianapolis & Louisville Ry. in the yards at Bloomington, Ind., Apr. 21.

Serious Wind Storms in the West continued their destruction to life and property during the past week. On Apr. 25, according to press reports, a train of three cars on the Union Pacific R.R. was derailed and overturned near North Loup, Neb., only the locomotive remaining on the rails. Twenty-nine passengers were injured. Houses were demolished on the same date at Uncas, Okla.; Ponca City, Kan., and elsewhere along the Kansas-Oklahoma state line. Reports state that near Broken Bow, Neb., a county schoolhouse was picked up by the wind while school was in session and carried half a mile.

On April 27-29 tornadoes were reported in southwestern and central portions of Oklahoma. Thirty-five persons were killed and about 100 others injured. The chief damage was done at the towns of Foss, Butler, Rogers, Hinton, Sentinel, Hobart, Lugert, Calumet and Eldorado, all in Oklahoma. At Lugart a Kansas City, Mexico & Orient Ry. passenger train was derailed by the wind.

In Childress County, Tex., seven persons were killed. Near Kirkland in this county, a work train on the Fort Worth & Denver City Ry. was blown from the track.

The Mississippi River Flood has been increased during the past week, owing to the heavy rains which have fallen throughout the valley. On Apr. 30 the U. S. Weather Bureau reports the river rising from St. Louis to below Cairo, falling from Cairo to Greenville, and rising from Vicksburg to the mouth. It was at that time once more above flood stage at St. Louis and Cairo. The Cumberland River, the Lower Tennessee and Lower Arkansas Rivers are also again in flood, and the Lower Ohio is rising rapidly. A stage of 48 ft. is expected at Cairo within the next ten days and from 21 to 22 ft. at New Orleans. The stages on Apr. 30 were as follows: St. Louis, 30.3; Cairo, 45.5; Memphis, 36.8; Arkansas City, 52.1; Helena, 51.3; Greenville, 45.6; Vicksburg, 47.9; Natchez, 49.7; Baton Rouge, 41.5; New Orleans, 20.4. This N Orleans stage is as high as the previous highest record. Great areas of country continue to be flooded, and the suffering is intense. Government, state and city relief expeditions are still cruising the flooded territory in the hope of relieving the inhabitants. A bill is expected to be passed through Congress this week appropriating a million and a half dollars to be devoted to the immediate reconstruction of broken levees.

The relative stages may be compared with those reported last week on page 814.

Soft Coal Must Not Be Used by railways in the Borough of Richmond, New York City. An order to this effect was issued Apr. 24 by the New York Board of Health to the Staten Island Rapid Transit Co. and the Baltimore & Ohio R.R.

Over a Hundred Billion Gallons of water are now in storage in the Croton drainage area of the water supply system of New York City. On Apr. 29, 1912, J. M. Bennett, deputy commissioner of water supply, informed this journal that every reservoir in the Croton area was full except Lake Mahopac, in which the water was within 4 ft. of the spillway. The actual amount of water stored at that time was 104,409,000,000 gal., as compared with 104,443,000,000 gal. total available capacity.

The Route for an East River Tunnel from Manhattan to Brooklyn, to be operated by the Brooklyn Rapid Transit Co. as a part of the dual plan for the New York subways extension, has been adopted by the New York Public Service Commission of the First District during the last week of April. This route departs from the Broadway subway in Manhattan at Trinity Place and Morris St., running through Beaver St. and Old Slip to the East River and under the river to Clark St., Brooklyn, continuing up Clark St. to a junction with another subway in Fulton St., Brooklyn, which will also be operated by the Brooklyn Rapid Transit Co. At the Manhattan end connection is also made with the Center St. loop subway, which connects the Williamsburg, Manhattan and Brooklyn bridges. This is the second tunnel to Brooklyn provided for by action of the Commission within a month, the other one being the Whitehall-Montague St. Tunnel, which will be used by the Interborough Rapid Transit Co. to connect the new Seventh Ave. subway in Manhattan with the Interborough lines in Brooklyn.

Work on the New York subways on Section 6 of the Lexington Ave. subway in Lexington Ave., between 26th St. and 40th St., was ordered discontinued Apr. 26 by the New York Public Service Commission. Work had been in progress for some months on this section when the receipt of an offer from the Interborough Rapid Transit Co. to join the city in constructing its part of the proposed dual system made it advisable to suspend work on this section for the reason that if the Interborough plan is carried out that company will take over the Lexington Ave. subway north of 42d St. and join it to the present subway south of 42d St., thus making needless the construction of a new subway in Lexington Ave. south of 42d St. The suspension of work probably will continue until the Commission and the Board of Estimate and Apportionment decide finally upon the proposed dual system.

On the Fourth Ave. subway in Brooklyn, about 87% of the work is finished. Work on Sections 4, 5 and 6, comprising that part of the subway on Fourth Ave. from Sackett St. to 43d St., is about 95% completed, and it is expected that most of Fourth Ave. will be finally repaved within ten weeks. Some 2900 men are now engaged in the completion of this subway.

Profits of 112%, according to the find- of the New York Public Service Commission, have been made by the Bridge Operating Co., which operates local cars over the Williamsburg bridge, New York City. The Bridge Operating Co. has a contract with the city, made by the Bridge Commissioner in 1904, authorizing it to operate local cars over the bridge and to charge 3c. for a single fare or 5c. for two tickets. The capital stock of the company is $100,000.

Following its investigation, the Commission issued an order reducing the fare for local service over the bridge [illegible] 2c. for a single ride or three tickets for 5c. The company made an application for a rehearing based mainly on the ground that the Commission has not the power to change rates of fare agreed upon in a contract between the city and the company. The Commission, however, holds that it has this power and has denied the application for a rehearing.

An Experimental Sewage Disposal plant is to be installed by the Borough of Richmond, New York City. The following outline of the experiments has been supplied to us by Theodor S. Oxholm, engineer-in-charge of the Bureau of Engineering Construction, Borough of Richmond, New Brighton, New York City:

It is the intention to use, as a basis for these experiments, the best methods adopted by the successful plants now established in this country and abroad where the conditions are somewhat similar to those existing in the Borough of Richmond.

Special study is to be made of preliminary treatment and the results of diffusion in tidal water after said treatment; prevention of nuisances by gases, and economical disposal of sludge.

The entire plant will be enclosed in a building, 53x90 ft., adjoining the West New Brighton refuse destructor in which so many interesting experiments have been made, and whose facilities for sludge disposal, electric power, etc., will be available for the sewage works.

Louis L. Tribus is consulting engineer and acting commissioner of public works, and George Cromwell is president of Richmond Borough.

An Experimental Sewage Treatment plant is proposed by the City of Indianapolis. We are informed by H. W. Klausmann, city engineer, that it will be some time before anything definite is done.

Working Models of the Panama Canal locks are to be exhibited by the United States Government at the 12th International Navigation Congress, to be held in Philadelphia, Penn., May 23 to 28. One of these models shows the whole of the Gatun Locks with mitering gates, emergency dams, fender chains, electric towing locomotive tracks, lamp posts, manholes and all accessories. The second model is on a scale of ½ in. = 1 ft. and represents a section of the lock walls with miter gate machinery, valves and fender chain machinery; in all essential features it is a replica in miniature of a lock section embracing the intermediate gates of a summit level lock of the canal. The model lock walls are built of cement mortar, and certain sections are removable to permit an examination of the valves and operating machinery.

A Gas Centenary Celebration was held in Philadelphia, Apr. 18 and 19, under the auspices of the American Philosophical Society, the American Chemical Society, the Franklin Institute and the American Gas Institute. The celebration commemorated the 100th anniversary of the granting of the first charter by the English Parliament for the incorporation of a gas company in the United States. Addresses were given as follows: "By-Products in Gas Manufacture," Prof. Charles E. Munroe, of George Washington University; "The Commercial and Financial Aspects of the Gas Industry," George B. Cortelyou, of New York City; "The Technique of Gas Manufacture," Alfred E. Forstall; "Gas as an Illuminant," V. R. Lansingh; "The Use of Gas for Heat and Power; the Testing of Gas," Edward B. Rosa, Washington, D. C.

Mr. Cortelyou in his address named Baltimore as the first city in the country to be lighted with gas and also the first city in which gas meters were manufactured. He stated that a gas company was organized in Boston, Mass., in 1821 and that New York City adopted gas lighting in 1823. In New York the price of gas in 1826 was $10 per 1000 cu.ft.; in 1846, $6; in 1866, $3.50; in 1886, $1.25; in 1906, 80c., the present rate.

Personals

Mr. Howard L. Ingersoll has been appointed Assistant General Manager of the New York Central & Hudson River R.R., at New York City.

Mr. H. F. Howe, Assoc. M. Am. Soc. C. E., has been promoted to be Chief Engineer of the Guayaquil & Quito Ry., at Guayaquil, Ecuador, succeeding Mr. A. A. Bond.

Mr. A. Travers-Ewell, formerly Chief Engineer of the Aporoma Goldfields, Ltd., of Tirapata, Peru, has returned to the United States and will open an office in Globe, Ariz., for the general practice of engineering.

Messrs. J. Hollis Wells and Charles H. Higgins, Ms. Am. Soc. C. E., consulting engineers of New York City and Jersey City, respectively, have been appointed members of the new City Plan Commission of Jersey City, N. J.

Mr. Jason Paige, Assoc. M. Am. Soc. C. E., recently Contracting Engineer of the Pittsburg Steel Products Co., at Chicago, Ill., is now with the sales department of McClernan & Co., with headquarters in the People's Gas Bldg., Chicago.

Mr. G. B. Herington has resigned his position as Chief Engineer of the Mountain Quarries Co., East Auburn, Calif., and has entered private practice as a consulting engineer with offices in the People's Bank Bldg., Sacramento, Calif.

Mr. A. J. Hammond, M. Am. Soc. C. E., Chief Engineer of the Bureau of Public Efficiency, Chicago, Ill., has been appointed Bridge Engineer of the Department of Public Works of Chicago, succeeding Mr. Thomas G. Pihlfeldt, resigned.

Mr. Charles W. Galloway, General Superintendent of the Baltimore & Ohio Southwestern R.R., at Cincinnati, Ohio, has been promoted to the position of General Manager of the Baltimore & Ohio R.R., with headquarters at Baltimore, Md.

Mr. T. McHattie has resigned as Superintendent of Motive Power of the Central Vermont R.R. to become Master Mechanic of the Eastern division of the Grand Trunk Ry., at Montreal, Que. He is succeeded on the Central Vermont R.R. by Mr. W. Gillespie.

Mr. Francis S. Foote, Jr., a member of the faculty of the School of Railway Engineering and Administration at the University of Illinois, has been appointed Associate Professor of Railway Engineering at the University of California, effective July 1, 1912.

Mr. Edwin Gould has resigned as President of the St. Louis Southwestern R.R., and has been elected Chairman of the Board of Directors. He is succeeded as President by Mr. F. H. Britton, formerly Vice-President and General Manager.

Mr. J. A. Heaman, Assoc. M. Can. Soc. C. E., has been promoted to be Division Engineer of the Grand Trunk Pacific Ry., at Fitzhugh, Alta., succeeding Mr. J. Callaghan, whose appointment as Chief Engineer of the Pacific Great Eastern Ry. was noted in our columns of last week.

Mr. Franklin B. Ware has resigned his position as State Architect of New York and will return to New York City, where he is a member of the architectural firm of James E. Ware & Son. Mr. Herman W. Hoefer, an architect of New York City, has been appointed by Governor Dix to succeed Mr. Ware.

Mr. H. M. Eicholtz, formerly Assistant Superintendent of the Chicago & Northwestern Ry., at Chicago, Ill., is now Superintendent of the same division, succeeding Mr. P. J. O'Brien, who resigned on account of ill health. Mr. J. G. Cowan, Assistant Superintendent at Clinton, Iowa, succeeds Mr. Eicholtz at Chicago.

Mr. C. L. Nichols, General Superintendent of the Northern Pacific Ry., at Livingston, Mont., has been appointed General Superintendent of the lines east of Paradise, with headquarters at St. Paul, Minn., succeeding Mr. E. C. Blanchard, whose promotion was noted in our issue of last week. Mr. Nichols began railway work in 1870 as a telegraph operator on the Chicago, Burlington & Quincy R.R.

Mr. Fred G. Simmons, for a number of years Superintendent of construction and maintenance-of-way of the Milwaukee Electric Railway & Light Co., has been appointed Commissioner of Public Works of Milwaukee, Wis., at a salary of $5000 per annum. Mr. Simmons studied engineering at the Colorado School of Mines, and for several years was Roadmaster of the Denver City Tramway Co., of Denver, Colo.

Mr. Louis J. Putnam has been appointed Division Engineer of the Chicago & Northwestern Ry. at Boone, Iowa. Mr. Putnam has been with the Chicago & Northwestern Ry. since 1899, when he started as an instrumentman. He graduated in civil engineering at Cornell College, Iowa, in 1903. He was Resident Engineer in charge of the Milwaukee, Wis., track elevation work and of the Escanaba, Mich., ore docks construction.

The members of the Bavarian Technical Museum Commission, whose arrival in this country was reported in our issue of Apr. 11, returned to New York on Apr. 25 after a two weeks' tour extending as far West as Chicago with a visit to Niagara Falls and New England. A luncheon was given in their honor at the Hotel Astor on Friday by the New York Peace Society. The Commission sailed for Germany on the "Augusta-Victoria" on Tuesday, Apr. 30.

Mr. Olin H. Landreth, M. Am. Soc. C. E., Professor of Civil Engineering at Union College, Schenectady, N. Y., has opened an office at 156 Fifth Ave., New York City, as a consulting engineer. Besides his duties and professional work at Schenectady he will devote a portion of each week to hydraulic, sanitary and valuation work in and about New York City. Prof. Landreth has recently been engaged by the city of Oswego, N. Y., to study a general system of sewerage and sewage disposal for that city.

Mr. J. M. Rapelje, Superintendent of the Idaho division of the Northern Pacific Ry., at Spokane, Wash., has been appointed General Superintendent of the lines west of Paradise, with headquarters at Livingston, Mont., succeeding Mr. C. L. Nichols, promoted, as noted elsewhere in these columns. Mr. A. M. Burt, Superintendent at Missoula, Mont., succeeds Mr. Rapelje at Spokane, and Mr. F. L. Birdsall, Superintendent at Jamestown, N. D., succeeds Mr. Burt. Mr. W. H. Strachan, Assistant Superintendent of the Lake Superior division at Duluth, Minn., has been promoted to be Superintendent at Jamestown, N. D., to succeed Mr. Birdsall.

Mr. C. H. Rust, M. Am. Soc. C. E., City Engineer of Toronto, Ont., for many years, will resign on May 15, to become City Engineer of Victoria, B. C., at a salary of $6500 per annum. Mr. Rust has spent 35 years in the service of the city of Toronto; entering its engineering department as a rodman he was steadily promoted to Deputy City Engineer, which position he held for 10 years. Fourteen years ago he was appointed City Engineer. In accepting his resignation the Board of Control of Toronto voted him an additional three months' salary as a testimonial of the city's appreciation of his 35 years of service. Mr. Rust is a past-president of the Canadian Society of Civil Engineers.

Obituary

Jacob E. Friend, President of the Nordberg Manufacturing Co., of Milwaukee, Wis., died on Apr. 20.

B. N. Robinson, a civil engineer employed on construction work on the Chicago, Burlington & Quincy R.R., was killed on Apr. 26, near Trempealeau, Wis., by a passing train.

David Findlay, Superintendent of Construction of the Calgary-Edmonton division of the Canadian Northern Ry., was killed near Winnipeg, Man., on Apr. 20, when the gasoline speeder on which he was riding collided with a locomotive.

Chester G. Wilkins, M. Am. Soc. M. E., Mechanical Engineer of the Thompson-Starrett Co., New York City, committed suicide on Apr. 20, by shooting himself at a sanitarium in Cold Spring, N. Y. Mr. Wilkins recently suffered from nervous prostration, brought on by overwork, and had been at the sanitarium about 10 days.

Horace J. Stevens, M. Am. Inst. M. E., compiler and publisher of "The Copper Handbook," died on Apr. 22, at his home in Houghton, Mich. He was born at Conewango, N. Y., in 1866 and began his business career as a country schoolmaster. In 1883 he went to Michigan and was employed in various capacities in the Beaufort mine on the upper Michigan peninsula. Later he was a reporter on the Marquette "Mining Journal." He had been known to mining engineers since 1901 for his handbook on copper mines, which has been published annually since that date.

Charles Beresford Fox, M. Can. Soc. C. E., died on Apr. 15 at the Cottage Hospital, Toronto, Ont. He was a son of Mr. Francis Fox, and a nephew of Sir Douglas Fox, both members of the Institution of Civil Engineers and among the most prominent civil engineers of England. Charles B. Fox had been a resident of Toronto for the past three years, previous to which he had been engaged in many important engineering enterprises abroad, including some years on the Rhodesian railways in South Africa, the construction of the bridge over the Zambesi River at Victoria Falls, the construction of the Assouan Dam in Egypt and the Simplon tunnel in Switzer-

land. Since coming to Toronto he had been in private practice with Mr. Edmund Wragge, M. Can. Soc. C. E.

Thomas Andrews, Jr., who was mentioned in our columns of last week as one of the engineers who lost their lives in the sinking of the "Titanic," was one of the managing directors of Harland & Wolff, of Belfast, builders of the "Titanic" and the "Olympic." He had been trained by the firm and had displayed great ability in the design and construction of both these monster steamships. Fourth Officer Boxhall of the "Titanic" is reported to have said that Mr. Andrews made an examination immediately after the collision and reported that the ship would sink in an hour. Afterward he returned to his post in the engine room to face there the end he knew was inevitable. Another member of the builders' staff who lost his life was R. Chisholm, Chief Shipyard Draftsman. He had been with the firm for many years and few were more experienced in the details of design of the present great merchant steamships. Not one of the engineering staff of the "Titanic" survived the disaster.

Engineering Societies

COMING MEETINGS

AIR BRAKE ASSOCIATION.
May 7-10. Annual convention at Richmond, Va. Secy., F. M. Nellis, 53 State St., Boston, Mass.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 14-16. Annual meeting at Chicago. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

MASTER BOILER MAKERS ASSOCIATION.
May 14-17. Annual convention at Pittsburg, Penn. Secy., H. D. Vought, 95 Liberty St., New York.

AMERICAN RAILWAY ASSOCIATION.
May 15. Semi-annual meeting at New York City. Secy., W. F. Allen, 75 Church St., New York.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS.
May 16-18. Annual meeting at Pittsburg, Penn. Secy., F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL RAILWAY FUEL ASSOCIATION.
May 22-25. Annual convention at Chicago, Ill. Secy., D. B. Sebastian, La Salle St. station, Chicago.

INTERNATIONAL NAVIGATION CONGRESS.
May 22-28. At Philadelphia, Penn. Secy., J. C. Sanford, 344 The Bourse, Philadelphia, Penn.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 28-31. Spring meeting at Cleveland, Ohio. Secy., C. W. Rice, 29 West 39th St., New York.

AMERICAN WATER WORKS ASSOCIATION.
June 3-8. Annual convention at Louisville, Ky. Secy., J. M. Diven, 271 River St., Troy, N. Y.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 4. Annual convention at New York City. Secy., P. W. Drew, Soo Line, Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 10-14. Annual meeting at Seattle, Wash. Secy., T. C. Martin, 29 West 39th St., New York.

MASTER CAR BUILDERS' ASSOCIATION.
June 12-14. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 17-19. Annual convention at Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago.

CANADIAN ELECTRICAL ASSOCIATION.
June 19-21. Annual meeting at Ottawa, Ont. Secy., T. S. Young, 220 King St., West, Toronto, Ont.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 25-28. Annual convention at Boston, Mass. Secy., F. L. Hutchison, 33 West 39th St., New York.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 25-28. Annual convention at Seattle, Wash. Secy., C. W. Hunt, 220 West 57th St., New York.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.
June 26-28. Annual meeting at Boston, Mass. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

Engineers' Society of Pennsylvania—We are advised by the secretary that no convention will be held this year by this society.

American Chemical Society—No meeting will be held during the coming summer, but instead the society will coöperate with the Eighth International Congress of Applied Chemistry, in Washington and New York, Sept. 4-13.

American Society of Civil Engineers—At the regular meeting, held May 1, in New York City, two papers were presented as follows: "Faults in the Theory of Flexure," by Henry S. Prichard, and "A Reinforced-Concrete Infiltration Well and a Pumping Plant," by Frederick M. Hatch. Mr. Prichard's paper was printed in the March issue and Mr. Hatch's paper in the April issue of the society's "Proceedings."

American Railway Association—At the spring session to be held in New York City at the Engineering Societies' Building, May 15, reports will be presented by the following committees: Executive Committee, Committee on Transportation, Committee on Maintenance, Committee on Relations Between Railroads, Committee on the Safe Transportation of Explosives and Other Dangerous Articles, Committee on Electrical Working and Committee on Nominations.

American Foundrymen's Association—The annual convention will be held at Buffalo, N. Y., Sept. 24-26, with headquarters at the Hotel Statler. A more than usually elaborate exhibition is promised. The postponement of the convention from the customary date in May is due to the delay in completing the new exhibition buildings at Buffalo. Owing to the unprecedented severity of the winter just passed, it was found impossible to complete these buildings, which are being built by the City of Buffalo, in time for the regular May gathering.

Engineering Association of the South—A committee appointed by the president of the Nashville section of this Association has drafted a letter on behalf of C. G. Elliott, until recently Chief of Drainage Investigations, copies of which have been sent to President Taft and to Secretary of Agriculture Wilson. The letter is reprinted below:

Sir—The Nashville Section of the Engineering Association of the South, by resolutions duly passed, desires to register strong and emphatic protest against what is regarded as the arbitrary, unjust and unreasonable action in the summary discharge of Mr. C. G. Elliott, Chief of Drainage Investigations.

Mr. Elliott is well known among his professional brethren and elsewhere, both for his practical work in drainage engineering and for his investigation of the general subject of land reclamation by drainage. Of his competency as an engineer and expert there is no question. Of his integrity, faithfulness and proper action in the public interest we consider that there is no question.

We do question the grounds upon which the action of the Department was based, and we cannot believe that the Department has acted fairly or in the public interest in its attack upon Mr. Elliott.

We desire to see Mr. Elliott reinstated and reparation made him, so far as reparation can be made after this attack upon his integrity. Also that any investigation shall be conducted in a competent, impartial and fair-minded manner, and not left to those who may have unworthy personal or political motives for avoiding a fair and full hearing.

(Signed) H. M. Gould, Pres.
W. Harwell Allen, Secy.
Nashville, Tenn., Apr. 23, 1912.

National Electric Light Association—The following program for the convention to be held in Seattle, June 11, 12 and 13 has been abstracted from a recent announcement:

GENERAL SESSIONS — Presidential Address, J. F. Gilchrist; "Expanded Loyalty," Paul Lupke; "The Desirability of a Central Station Load of Pumping for Municipal Waterworks," C. A. Monroe; "Educating Central Station Employees," H. E. Grant; "Some Uses of Metals," W. R. Whitney; reports of Secretary and Insurance Expert; report of committees on (1) Organization of the Industry, (2) Progress, (3) Library, (4) Handbook, (5) Question Box, (6) Rate Research, (7) Street Lighting, (8) Memorials, (9) Constitutional Amendments, (10) Nominations, (11) Award of Doherty Medal, (12) Public Policy, (13) Resuscitation Commission.

TECHNICAL SESSIONS—"Meter Setting," S. D. Sprong; "Line Voltage," R. E. Campbell; "Use of Electricity for Irrigation and Agriculture," B. H. Williams; "Work and Publications of U. S. Government on Hydro-electric Developments," J. S. Hoyt; "Switchboard Practice for High-Tension Power Transmission," S. Q. Hayes; "Care and Operation of Transformers," W. M. McConahey; "Corona on High-Tension Lines," G. Facchioli. Reports of committees on (1) Meters, (2) Grounding Secondaries, (3) Lamps, (4) Electrical Measurements, (5) Power Transmission, (6) Power-Transmission Progress, (7) Prime Movers, (8) Electrical Apparatus, (9) Underground Construction, (10) Receiving Apparatus for Transmission Lines (11) Protection from Lightning and Static Disturbances.

COMMERCIAL SESSIONS—"Commercial Development of the Electrical Industry," W. W. Freeman; "Electricity in Rural Districts," J. G. Learned; "A Plan for Increasing Power Loads," H. W. Cope; "Selling Current to Larger Power Users," Joseph Lukes; "Ozonators and Their Exploitation," M. O. Troy. Reports of committees on (1) Membership, (2) Steam Heating, (3) Electric Refrigeration and Ventilation, (4) Residential Business, (5) Industrial and Commercial Lighting, (6) Competitive Illuminants, (7) Electric Advertising and Decorative Street Lighting, (8) Electric Vehicles, (9) Cost of Commercial Department Work, (10) Contract Order Routine, (11) Commercial Index.

ACCOUNTING SESSION — "Incandescent Lamp Accounting of the New York Edison Co.," W. H. Bogart; "Accounting for Scrap Material," T. E. Bowden; "General Filing Systems," R. H. Williams; "Proper Accounting for the Sale of Electric Devices," L. M. Wallace; "Scientific Management of an Accounting Department," F. Heydecke; "Central Stations Motor Vehicle Costs and Their Distribution to Accounts Benefited," E. C. Scobell; "Regulated Electric-Light Accounting," H. M. Edwards; "Progress Made in Uses of Tabulating Machines," M. R. Schmidt.